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DEPARTMENT OF THE ARMY TECHNICAL MANUAL

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HYDRAULIC TURRET-TRAVERSING AND GUN-ELEVATING SYSTEM FOR 76-mm. GUN TANK T41E1 AND 90-mm. GUN TANK M47

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HYDRAULIC
TURRET-TRAVERSING
AND GUN-ELEVATING
SYSTEM FOR
76-mm. GUN TANK T41E1
AND 90-mm. GUN TANK
M47



DEPARTMENT OF THE ARMY

OCTOBER 1952

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CHAPTER 1

INTRODUCTION

Section I. GENERAL

1. Scope

a. This manual is published for the information and guidance of personnel responsible for field and depot maintenance of the turret-traversing and gun-elevating system of the 90-mm gun tank M47. It contains information on description, principles of operations, and trouble shooting which is beyond the scope of the using organization.

b. TM 9-718A contains operating and lubricating instructions for the matériel and covers all maintenance operations allocated to using organizations.

c. This first edition manual is published in advance of complete technical review. Any errors or omissions will be brought to the attention of the Chief of Ordnance, Washington 25, D. C., ATTENTION: ORDFM—Pub.

2. Field and Depot Maintenance Allocation

The publication of instructions for complete disassembly and rebuild is not to be construed as authority for the performance by field maintenance units of those functions which are restricted to depot shops and arsenals. In general, the prescribed maintenance responsibilities will be reflected in the allocation of maintenance parts listed in the appropriate columns of Department of the Army Supply Catalog ORD 8 SNL G-262. Instructions for depot maintenance are to be used by maintenance companies in the field only when the tactical situation makes the repair functions imperative. Supply of parts listed in the depot guide column of ORD 8 SNL G-262 will be made to field maintenance only when the emergency nature of the maintenance to be performed has been certified by a responsible officer of the requisitioning organization.

3. Forms, Records, and Reports

a. *General.* Responsibility for the proper execution of forms, records, and reports rests upon the officers of all units maintaining this

equipment. However, the value of accurate records must be fully appreciated by all persons responsible for their compilation, maintenance, and use. Records, reports, and authorized forms are normally utilized to indicate the quantity and condition of matériel to be inspected, to be repaired, or to be used in repair. Properly executed forms convey authorization and serve as records for repair or replacement of matériel in the hands of troops and for delivery of matériel requiring further repair to ordnance shops in arsenals, depots, etc. The forms, records, and reports establish the work required, the progress of the work within the shops, and the status of the matériel upon completion of its repair.

b. Authorized Forms. No forms other than those approved for the Department of the Army will be used. For current and complete listing of all forms, refer to current SR 310-20-6. Additional forms applicable to the using personnel are listed in the operator's manual. For instructions on use of these forms, refer to FM 9-10.

c. Field Reports of Accidents. The reports necessary to comply with requirements of the army safety program are prescribed in detail in the SR 385-10-40 series of special regulations. These reports are required whenever accidents involving injury to personnel or damage to matériel occur.

d. Reports of Unsatisfactory Equipment or Materials. Any suggestions for improvement in design and maintenance of equipment, safety and efficiency of operation, or pertaining to the application of prescribed lubricants and/or preserving materials, will be reported through technical channels as prescribed in SR 700-45-5 to the Chief of Ordnance, Washington 25, D. C., ATTN: ORDFM, using DA Form 468, Unsatisfactory Equipment Report. Such suggestions are encouraged in order that other organizations may benefit.

Note. Do not report all failures that occur. Report only **REPEATED** or **RECURRENT** failures or malfunctions which indicate unsatisfactory design or material. However, reports will always be made in the event that exceptionally costly equipment is involved. See also SR 700-45-5 and the printed instructions on DA Form 468.

Section II. DESCRIPTION, PRINCIPLES OF OPERATION, AND DATA

4. Description

(fig. 1)

a. General. The turret-traversing and gun-elevating system incorporated in the 90-mm gun tank M47 consists of mechanical, electrical, and hydraulic components arranged to produce the required movements and control of the gun and turret.

b. *Gunner's Manual Traversing System*. The gunner's manual traversing system consists basically of the following components: a traverse crank handle, a hand drive, a shifting mechanism, a traversing mechanism, and the turret ring gear.

c. *Gunner's Manual-Hydraulic Elevating System*. The gunner's manual-hydraulic elevating system consists basically of the following components: a hand-operated elevating pump, a selector valve, an accumulator, a hand-operated supercharge pump, hydraulic swivel joints, an elevating cylinder, an oil reservoir, and hydraulic lines.

d. *Gunner's or Commander's Hydraulic-Power Traversing System*. The gunner's or commander's hydraulic-power traversing system consists basically of the following components: a gunner's control, a commander's control, an override control box, a pulsing relay box, a power pack (which incorporates an electric drive motor, a gear case, two hydraulic pumps, an oil reservoir, two signal motors, and hydraulic control mechanisms), a hydraulic motor, a traversing mechanism, and the turret ring gear.

e. *Gunner's or Commander's Hydraulic-Power Elevating System*. The gunner's or commander's hydraulic-power elevating system consists basically of the following components: a gunner's control, a commander's control, an override control box, a pulsing relay box, a power pack (d above), a selector valve, hydraulic swivel joints, an oil reservoir, and hydraulic lines.

5. Principles of Operation

(fig. 2)

a. General.

- (1) The turret-traversing and gun-elevating system (figs. 1 and 2), enables either the gunner or crew commander to traverse the turret and/or elevate or depress and fire the gun quickly and accurately with a minimum of effort. The commander's control has a switch which enables the commander to override the gunner.
- (2) The controlled drive traverses the turret through any angle in either direction, at any tracking rate up to a maximum of 1.7 rpm, and elevates the gun 19° above the horizontal or depresses the gun 10° below the horizontal, at any tracking rate up to a maximum of 1.5° per second.

Note: Slew switches incorporated in the controls permit the turret to be traversed at a maximum speed of 4 rpm and/or the gun to be elevated or depressed at a maximum speed of 4° per second.

b. *Gunner's Manual Traversing*. The gunner's manual traversing is performed by means of the hand drive, the shifting mechanism, and

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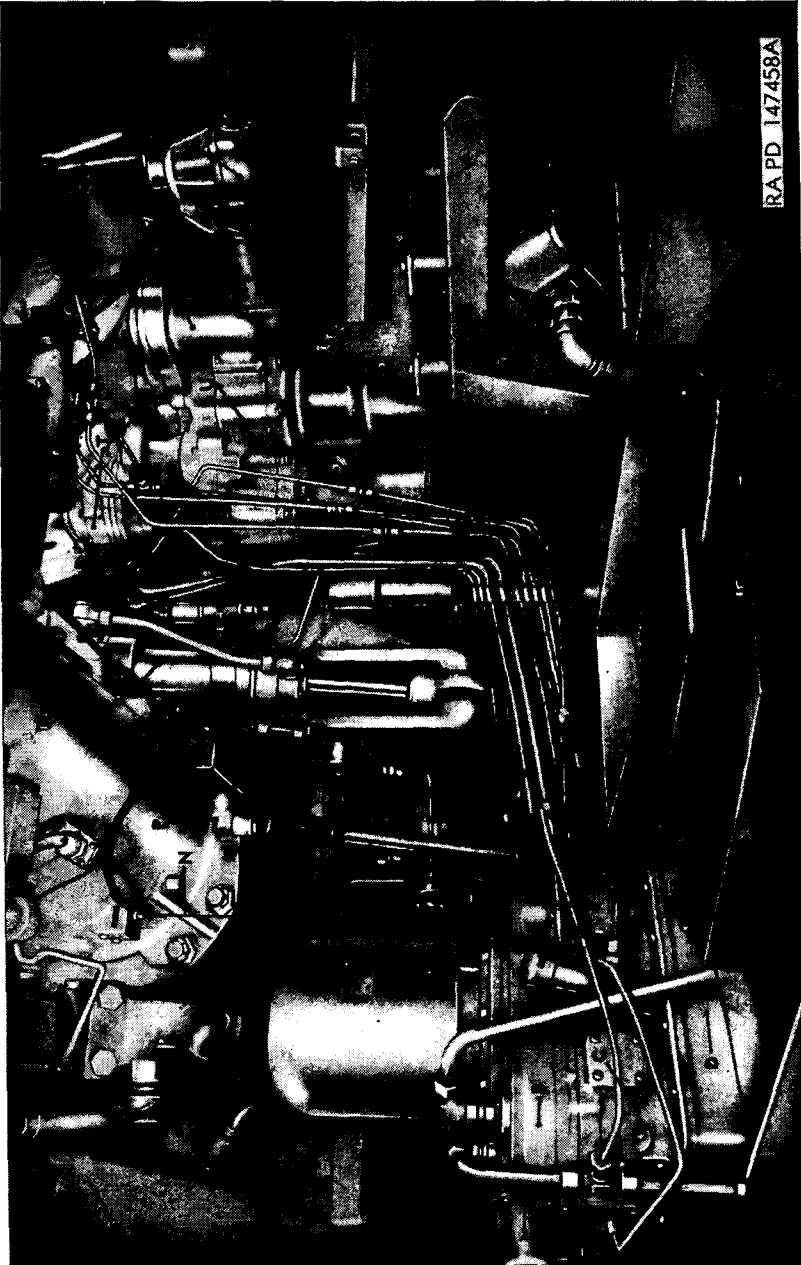


Figure 1. Turret-traversing and gun-elevating system components.

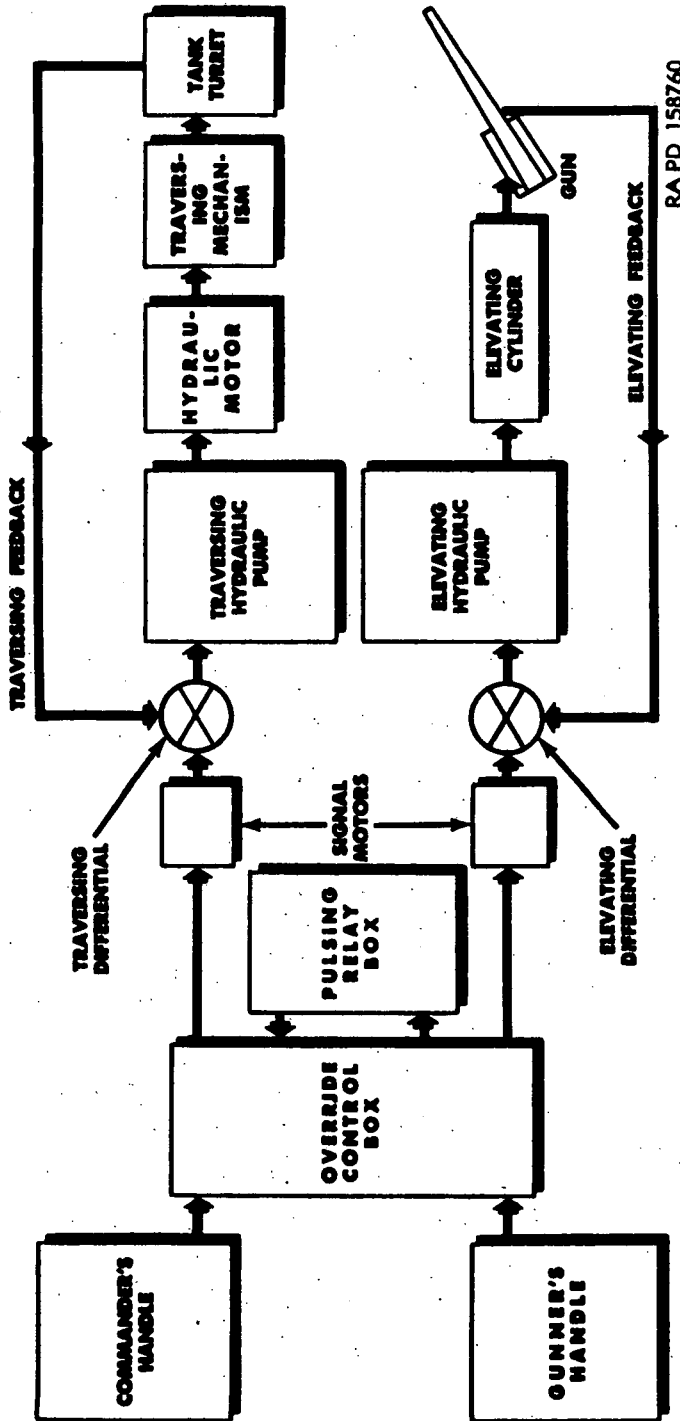
Figure 1—Continued

A—TURRET-TRAVERSING SIGNAL MOTOR
B—DRIVE GEAR CASE
C—TURRET-TRAVERSING HYDRAULIC PUMP
D—RESERVOIR
E—FILLER PIPE CAP
F—GUN-ELEVATING HYDRAULIC PUMP
G—HAND-OPERATED SUPERCHARGE PUMP
H—ACCUMULATOR
J—ELECTRIC DRIVE MOTOR
K—TURRET RING GEAR
L—HYDRAULIC SWIVEL JOINT
M—SUPERCHARGE PUMP HANDLE
N—ELEVATION FEED-BACK CABLE
P—HYDRAULIC-SWIVEL-JOINT MANIFOLD
Q—ELEVATING CYLINDER
R—DUMP-VALVE SOLENOID
S—DUMP VALVE
T—TURRET-TRAVERSING HYDRAULIC MOTOR
U—TRAVERSING MECHANISM
V—SLIP CLUTCH
W—NO-BACK DEVICE
X—TRAVERSE CRANK HANDLE
Y—HAND DRIVE
Z—GUNNER'S SEAT
AA—OVERRIDE CONTROL BOX
BB—PULSING RELAY BOX

the traversing mechanism (fig. 1). The gunner rotates the traverse crank handle (fig. 1) in the direction that he wishes to traverse the turret. A release lever on the crank handle actuates an electro-hydraulic dump valve (fig. 1), which dumps hydraulic pressure and allows an undelayed shift from power to manual traverse. The rate of rotation of the turret depends on the rate of rotation of the handle. Manual effort is transmitted from the hand drive to the traversing mechanism via a gear reduction system, a no-back lock, a slip clutch, a differential, and the planetary gear systems (fig. 73). The traversing mechanism transmits this effort to the two pinion gears (fig. 73) which mesh with the turret ring gear to traverse the turret. Any external force tending to turn the turret, eg, the gun striking an object, will act on the driven side of the no-back lock (fig. 74). This will lock the no-back lock and cause the slip clutch to slip. The locking action (fig. 74) prevents the hand drive from being turned by the traversing mechanism, thereby protecting the gunner from injury by the crank handle.

c. *Gunner's Manual-Hydraulic Elevating or Depressing.* The gunner's manual-hydraulic elevating or depressing system is essentially a hand-operated hydraulic system acting independent of the power hydraulic system. The gunner turns the hand-operated elevating pump (fig. 84) in either direction depending on whether he wishes to elevate or depress the gun. The rate of elevation or depression of the gun is dependent on rotation of the hand-operated elevating pump. The hand-operated elevating pump forces hydraulic fluid through the selector valve into either end of the gun-elevating cylinder. Pumping hydraulic fluid into one end of the elevation cylinder will elevate the gun; pumping hydraulic fluid into the other end of the cylinder will depress the gun. The elevating cylinder (fig. 1) is connected at one end to the hull of the turret and at the other end to the cradle of the 90-mm gun. A hand-operated supercharge pump (fig. 1), draws hydraulic fluid from the reservoir and pumps it into an accumulator until the accumulator is charged with reserve hydraulic fluid and the system is charged to the supercharge pressure. The accumulator acts as a pressure reservoir in the gunner's manual elevating hydraulic system to maintain pressure and to compensate for changes in the volume of hydraulic fluid caused by temperature changes and minor leaks in the gunner's manual elevating hydraulic system. A precharge gas-filled bag in the accumulator exerts pressure against the hydraulic fluid.

d. *Gunner's or Commander's Hydraulic Power Traversing.* Controlled fluid power for training and traversing turret quickly and accurately is supplied by a two-way variable-delivery hydraulic pump



RA PD 158760

Figure 2. Turret-traversing and gun-elevating system—schematic.

(fig. 1), mounted in the power pack and driven by the electric drive motor. This pump delivers oil in either direction through two hydraulic lines to a constant-displacement hydraulic motor mounted on the traversing mechanism (fig. 1). Built into the traversing pump is a constant-delivery gear pump which supercharges the traversing hydraulic pump (fig. 1), and the hydraulic motor system, and supplies fluid power to disengage the hand drive from the traversing mechanism. Two pistons of a four-piston supercharge hydraulic dither pump, built into elevating pump, alternately withdraw oil from and inject oil into the traversing system at a rapid rate to create pulsations of pressure. These pulsations maintain an intermittent high pressure in the traversing system and set up vibrations in certain movable parts in the hydraulic motor and traversing mechanism so that the hydraulic motor shaft can respond instantly in the demands of the control. Any volume of oil up to a maximum is delivered in either direction by the traversing hydraulic pump in response to a traversing differential mounted on the traversing hydraulic pump. An electric signal motor (fig. 1) drives the first leg of the differential, a feedback gear and shaft from the turret ring gear drives the second leg of the differential, and dual-opposed hydraulic servo-motor pistons move pump slide block in response to the third leg of the differential. Both the speed and direction of electric signal motor operation is selected by the degree and direction of movement of the gunner's control handle or the commander's control handle. Commander's control can override gunner's control. Releasing control handle or moving them back to neutral position stops turret movement.

e. Gunner's or Commander's Hydraulic Power Elevating or Depressing. Controlled fluid power for elevating and depressing the gun quickly, smoothly, and accurately is supplied by a two-way variable-delivery hydraulic pump (fig. 1), mounted in the power pack and driven by the electric drive motor. This pump delivers oil in either direction through two hydraulic lines and a selector valve to a nondifferential, double-ram, clevis mounted elevating cylinder. Oil from the constant-delivery gear pump, built into the traversing hydraulic pump, supercharges the elevating hydraulic pump and the elevating cylinder system; the gear pump supplies fluid power to the control pistons in the elevating pump and actuates and holds the selector valve plungers in power operation positions. Two pistons of a four-piston supercharge hydraulic dither pump alternately withdraw oil from and inject oil into the elevating system at a rapid rate to create pulsations of pressure. These pulsations maintain an intermittent high pressure in the elevating system and set up vibrations in the elevating cylinder so that the cylinder can

respond instantly to the demands of the control. Any volume of oil to maximum is delivered in either direction by the hydraulic elevating pump in response to a differential control mounted on the elevating pump. A small electric signal motor drives the first leg of the differential, a spring-loaded cable from the gun drives the second leg of the differential and dual-opposed hydraulic servo-motor pistons move pump slide block in response to the third leg of the differential. Both the speed and direction of the electric signal motor operation is selected by the degree and direction of movement of the gunner's control handle or the commander's control handle. Commander's control can override gunner's control. Releasing control handles or moving them back to neutral position stops elevating or depressing of gun.

6. Data

Traverse of turret-----through any angle in either direction
Tracking rate of power traverse of turret (min) -----0.3 mil per sec
Tracking rate of power traverse of turret (max) -----1.7 rpm
Slew rate of power traverse of turret (max) -----4 rpm
Depression of gun below horizontal (max) -----10° (178 mils)
Elevation of gun above horizontal (max) -----19° (338 mils)
Tracking rate of power elevation of gun (max) -----1.4° per sec
Slew rate of power elevation of gun (max) -----3.4° per sec

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CHAPTER 2

TROUBLE SHOOTING

7. General

Notes. Information in this chapter is for use of ordnance maintenance personnel in conjunction with and as a supplement to the trouble shooting section in TM 9-718A. It provides the combination of instructions where a remedy in TM 9-718A refers to ordnance maintenance personnel for corrective action.

Operation of a deadlined vehicle without a preliminary examination can cause further damage to a disabled component and possible injury to personnel. By careful inspection and trouble shooting such damage and injury can be avoided and, in addition, the causes of faulty operation of a vehicle or component can often be determined without excessive disassembly.

8. Instructions and Procedures

This chapter contains inspection and trouble shooting procedures to be performed while a disabled component is still mounted in the vehicle and after it has been removed.

a. The inspections made while the component is mounted in the vehicle are for the most part visual and are to be performed before attempting to operate the vehicle. The object of these inspections is to avoid possible damage or injury and also to determine the condition of and, when possible, what is wrong with the defective component.

b. The trouble shooting performed while the component is mounted in the vehicle is that which is beyond the normal scope of the using organization. Check the trouble shooting section of TM 9-718A, then proceed as outlined in this chapter. These trouble shooting operations are used to determine if the fault can be remedied without removing the component from the vehicle and also, when subsequent removal is necessary, to indicate when repair can be made without complete disassembly of the component.

c. Inspection after the component is removed from the vehicle is performed to verify the diagnosis made when the component was in

the vehicle, to uncover further defects, or to determine faults if the component alone is received by the ordnance establishment. This inspection is particularly important in the last case because it is often the only means of determining the trouble without completely disassembling the component.

9. Pulsing Relay System

a. General.

- (1) *Description* (fig. 2). The turret electrical system consists of the pulsing relay system (turret-traversing system, gun-elevating system, and fire-control system) cal. 50 ammunition feed control system, and the turret accessories system. In trouble shooting the pulsing relay system, the trouble should first be traced to one of the aforementioned systems, and then the faulty component can be isolated.
- (2) *Turret-traversing system* (fig. 3). Electrically, the turret power is supplied by an electric drive motor (fig. 1), which actuates a double hydraulic pump. The output power from the traversing pump is controlled by the turret-traversing signal motor in conjunction with a pulsing relay. Speed and direction of the signal motor in the pulsing relay system is controlled by either the gunner's control handle or the commander's control handle through cables Nos. 608, 608A, 609, and 610. The electrical harness from these two handles passes through the override control box. Within this box are the override relays (series 1 override control box has two, series 2 override control box has three) (figs. 29 and 31), which transfer control from the gunner's control handle to the commander's control handle when the override lever (fig. 4) in the pistol grip of the commander's control handle is actuated. However, neither the gunner's nor the commander's control is operative unless the loader's traversing safety switch, the turret control switch (fig. 6), and the master relay switch are all in the "ON" positions. The safety switch and the control switch (in series) operate a contactor in the override control box which connects the electric drive motor positive feed cable No. 100 to the slip ring positive feed cable No. 100.
- (3) *Gun-elevating system* (fig. 3). The power for driving the depressing the 90-mm gun, comes from the same electric elevating pump, which supplies the power for elevating or drive motor that is used for traversing the turret. The output power from the elevating pump is controlled by the gun-

elevating signal motor in conjunction with a pulsing relay. Speed and direction of the signal motor in the pulsing relay system is controlled by either the gunner's control handle or the commander's control handle through cables Nos. 600, 600A, 601, and 602. The electrical harness from these two handles passes through the override control box. Within this box are the override relays which transfer control from the gunner's control handle to the commander's control handle when the override lever is actuated. However, neither the gunner's nor the commander's control is operative unless the turret control switch (fig. 6), the traversing safety switch, and the master relay switch are all in their "ON" positions. The traversing safety switch and turret control switch operate a contactor in the override control box which connects the electric drive motor feed cable No. 100. An elevating limit switch opens up control cable No. 601 when the gun reaches 19° above horizontal and the depressing limit switch opens up control cable No. 602 when the gun reaches 10° below horizontal.

- (4) *Fire-control system.* The firing mechanism on the 90-mm gun consists of a timing relay, a firing relay, and a firing solenoid. The timing relay is connected by cable No. 113, through the turret filter box, into the gunner's control handle where it passes through the 90-mm gun firing selector switch (fig. 6) into the gunner's firing triggers (fig. 27). The contacts of the timing relay are connected by cable No. 102 to the firing relay. The contacts of the firing relay are connected by cable No. 115 to the firing solenoid through the loader's safety relay. The loader's safety relay is actuated by the loader's safety switch reset button. The cal. .50 gun-firing solenoid is connected by cable No. 103 through the filter box into the gunner's control handle where it passes through the cal. .50 gun-firing selector switch (fig. 6) into the gunner's trigger switches. The two gunner's trigger switches are wired in parallel and connected by a single cable (cable No. 103-113) to the trigger switch on the commander's control handle (fig. 21).

b. Preliminary Instructions.

- (1) *Preparing for operation.* Remove the travel lock from the gun and lay the travel lock down on the hull of the tank. Release the turret travel lock under the commander's seat by turning the handle clockwise. Check to see that the system switch is in the "OFF" position. Traverse the tur-

ret through 360° and elevate the gun from its lowest to its highest position manually to be sure that no obstructions are present.

- (2) *Check power turret control system.*
 - (a) Turn the tank master switch in the driver's compartment to the "ON" position.
 - (b) Start the auxiliary generator or run the main engine.
 - (c) Move the turret control switch lever (fig. 6) to the "ON" position and note that the turret control switch signal light turns on.
 - (d) Move the traversing safety switch to the "ON" position, starting the electric drive motor on the power pack.
 - (e) Using the gunner's control handle traverse the turret through 360° and elevate the gun from its lowest to its highest position and back again, to remove all air from the hydraulic system and allow the system to fill with oil.
- (3) *Check traversing minimum and maximum tracking rates and slewing speed.* Move the gunner's control handle a few degrees clockwise to close the signal motor field switch in the handle. The turret should traverse at approximately 0.3 mil per second. Move the gunner's control handle clockwise to its stop and check the traversing slewing speed. The turret should slew at approximately 4 rpm. Slowly allow the control handle to return toward its center position, stopping it just as the slewing switch opens and check the traversing maximum tracking rate. The traversing maximum tracking rate should be 175 mils per second. Repeat in the opposite direction. Repeat, using the commander's control handle.
- (4) *Check elevating maximum tracking rate and slewing speed.* Move the control handle to its stop in the elevating direction and check the elevating maximum slewing speed. The gun should slew at approximately 60 mils per second. Slowly allow the control handle to return toward its center position, stopping it just as the slewing switch opens and check the elevating maximum tracking rate. It should be approximately 25 mils per second. Repeat in the opposite direction. Repeat, using the commander's control handle.
- (5) *Check elevating and depressing limit switches.* The two limit switches (fig. 11) should shut off the electrical system when the gun has nearly reached the stops in the turret. Elevate and depress the gun to its extreme positions to check the limit switches.

c. Turret Cannot be Traversed or Gun Elevated by Either Gunner's or by Commander's Control Handle.

- (1) *Control switches not set.* Make sure the master relay switch turret control switch (fig. 6), and loader's power safety switch are all in the "ON" position.
- (2) *Electric drive motor not running.*
 - (a) *Open circuit in turret slip ring.* Disconnect cable No. 100 from turret slip ring box. Using a voltmeter, check for presence of voltage at electrical receptacle. If voltage is not present, turn off master relay switch and disconnect cable No. 47 (in hull) at turret slip ring box. Using an ohmmeter, determine the resistance between the two electrical receptacles. An infinite resistance indicates an open slip ring. Replace the turret slip ring box.
 - (b) *Open circuit in cable from slip ring box to override control box.* Turn off master relay switch and disconnect cable No. 100 from turret slip ring box and override control box (fig. 3). Using an ohmmeter, determine the resistance between the two connector plugs. An infinite resistance indicates an open cable. Replace cable.
 - (c) *Failure of turret control switch (fig. 25).* Turn master relay switch to "OFF" position. Disconnect connector No. 109 (fig. 3) from gunner's control handle. Place turret control switch on "ON" position. Using an ohmmeter, check resistance between pin "A" and pin "B" of electrical receptacle No. 109. An infinite resistance indicates a faulty switch. Replace turret control switch in gunner's control handle.
 - (d) *Failure of 200 amp circuit breaker in override control box (figs. 29 and 31).* Turn master relay switch to "OFF" position. Connect the "A" and "B" pins of connector No. 103 from the traversing safety box with a jumper cable. Listen for the snap of the circuit breaker contactor. Place an ohmmeter from connector No. 100 for the turret motor to the "A" pin. An infinite resistance indicates a faulty circuit breaker. Replace circuit breaker.
 - (e) *Failure of loader's power safety switch.* Turn master relay switch to "OFF" position. Remove loader's power safety box from mounting bracket. Place switch in "ON" position. Using an ohmmeter, check resistance through switch. An infinite resistance indicates a faulty switch. Replace loader's power safety switch.

- (f) *Failure of electric drive motor relay in override control box* (figs. 29 or 31). Turn master relay switch to "OFF" position. Disconnect connector No. 103 (fig. 3) from override control box. Using an ohmmeter, check resistance from pin "13" to ground. An infinite resistance indicates a faulty relay. Replace electric drive motor relay.
 - (g) *Open circuit in cable from override control box to electric drive motor*. Turn master relay switch to "OFF" position. Disconnect connector No. 101 from override control box (fig. 3). Disconnect cable No. 100 from electric drive motor. Using an ohmmeter, check resistance between the two connector plugs. An infinite resistance indicates an open cable. Replace cable.
 - (h) *Failure of electric drive motor*. Turn power switch to "ON" position. Disconnect cable No. 100 from electric drive motor. Using a voltmeter, check presence of voltage at connector plug. Presence of voltage with motor not running indicates a faulty motor. Replace electric drive motor.
- (3) *Neither signal motor is running.*
- (a) *Preliminary check*. Turn the loader's safety switch and the master switch to the "ON" position. With the control switch on the gunner's control handle in the "ON" position, throw the handle into slew and listen at the power pack for signal motor rotation. If the signal motors cannot be heard running, remove them from the power pack and check for mechanical binding by spinning the gears (fig. 10) with the fingers. If there is no binding check for open circuit with an ohmmeter between the terminals A and D, B and D, and C and D. Infinite resistance between any two indicates broken winding. Replace if found defective, or proceed to (b).
 - (b) *Failure of both pulsing relays or their associated circuits* (figs. 33 and 34). Using an ohmmeter, check resistance of cables in harness from override control box to pulsing relay box (fig. 3), and harness from override control box to signal motors. An infinite resistance indicates a faulty cable. If either harness is found defective, replace harness. If neither harness is faulty, replace pulsing relay box.
- d. *Turret Cannot be Traversed or Gun Elevated by Commander's Control Handle (Gunner's Control Operates System).*
- (1) *Override switch is open*. Turn master relay switch to "OFF" position. Disconnect connector No. 107 (fig. 3) from com-

mander's control handle. Depress override lever (fig. 20). Using an ohmmeter, check resistance between pin "A" and pin "B" of electrical receptacle. An infinite resistance indicates a faulty switch. Replace override switch (fig. 21).

- (2) *Open circuit in harness between commander's control handle and override control box.* Turn master relay switch to "OFF" position. Disconnect connector No. 107 (fig. 3) from commander's control handle. Disconnect connector No. 106 from override control box. Using an ohmmeter, check resistance of cables in harness. An infinite resistance indicates a faulty cable. Replace harness.
- (3) *Failure of override relays.* Remove cover from override control box. Turn master relay switch and turret control switch (fig. 6) to "ON" position. Turn loader's power safety switch to "OFF" position. Operate override lever, and check operation of override relays (figs. 29 or 31) (two relays in series 1 and three relays in series 2). If relays fail to operate, replace override relays.

c. *Turret Cannot Be Traversed or Gun Elevated by Gunner's Control Handle (Commander's Control Operates System).*

- (1) *Preliminary check.* Manual traversing crank handle (fig. 1) must be in neutral position so that locking latch will engage dump valve micro-switch.
- (2) *Commander's override switch stuck closed.* Turn master relay switch and turret control switch to "ON" position. Check operation of commander's override switch (fig. 21) on commander's control handle. Actuate override lever and check resistance between pins "A" and "B," of electrical receptacle 107. Infinite resistance indicates a faulty override switch. Replace override switch.
- (3) *Override relays stuck closed.* Remove cover from override control box (figs. 29 or 31). Turn master relay switch and turret control switch (fig. 6) to "ON" position. Turn loader's power safety switch to "OFF" position. Depress override lever on commander's control handle (fig. 21). Check operation of override relays. Disconnect connectors Nos. 102 and 105 from override control box. With override lever released, an infinite resistance between pin "C" of connector 102 and pin "C" of connector 105, between pin "D" of connector 102 and pin "D" of connector 105, or between pin "F" of connector 102 and pin "G" of connector 105 on the override control box indicates a stuck relay (fig. 12). Replace defective override relays.

- (4) *Open circuit in harness between gunner's control handle and override control box (fig. 3).* Turn master relay switch to "OFF" position. Disconnect connector No. 109 from gunner's control handle. Disconnect connector No. 102 from override control box. Using an ohmmeter, check resistance of cables in harness. An infinite resistance indicates a faulty cable. Replace harness.
- (5) *Open circuit in gunner's control handle.* When the above faults fail to correct trouble turn master relay switch to "OFF" position. Replace potentiometer bracket assembly (fig. 24).

f. Turret Cannot Be Traversed by Either Gunner's or Commander's Control Handle.

- (1) *Preliminary check.* Manual traversing crank handle (fig. 1) must be in neutral position so that locking latch will engage dump-valve micro-switch. To determine whether or not the failure is electrical or hydraulic, turn loader's power safety switch to "OFF" position. Turn master relay switch and turret control switch (fig. 6) to "ON" position. Operate gunner's control handle (fig. 24) in elevation and traverse and listen for operation of pulsing relay box and turret-traversing signal motor. If motor runs in both directions, refer to paragraph 10. If motor does not run, proceed with following steps (2) through (6).
- (2) *Open circuit in turret-traversing signal motor.* Turn master relay switch to "OFF" position. Disconnect connector plug from turret traversing signal motor (fig. 3). Check signal motor for open circuit per paragraph 9c(3)(a). Replace signal motor if defective.
- (3) *Open circuit in harness between turret-traversing signal motor and override control box.* Turn master relay switch to "OFF" position. Disconnect connector No. 105 from override control box (fig. 3). Disconnect connector plug from turret traversing signal motor. Using an ohmmeter, check resistance of cables in harness especially circuit 608. An infinite resistance indicates an open cable. Replace harness.
- (4) *Open circuit in harness between pulsing relay box and override control box.* Turn master relay switch to "OFF" position. Disconnect connector No. 114 from override control box (fig. 3). Disconnect connector plug from pulsing relay box. Using an ohmmeter, check resistance of cables in harness. An infinite resistance indicates an open cable. Replace harness.

- (5) *Faulty operation of override relays* (figs. 29 or 31). Remove cover from override control box. Turn master relay switch and turret control switch (fig. 6) to "ON" position. Turn loader's power safety switch to "OFF" position. Operate override lever, and check operation of override relays. Check relay contacts for good circuit connection. If operation is faulty, replace override relays.
- (6) *Failure of pulsing relay*. Turn master relay switch and turret control switch to "ON" position. Turn loader's power safety switch to "OFF" position. Disconnect connector No. 105 from override control box (fig. 3). Displace gunner's control handle for traversing from neutral position. Using a voltmeter, check presence of voltage between pin "A" and pin "B" of electrical receptacle. If voltage is not present, replace defective traversing chassis assembly in pulsing relay box (fig. 33).

g. 90-mm Gun Cannot Be Elevated or Depressed by Either Gunner's or Commander's Control Handle.

- (1) *Preliminary check*. Determine whether or not the failure is electrical or hydraulic. Turn loader's power safety switch to "OFF" position. Turn master relay switch and turret control switch to "ON" position. Operate gunner's control handle (fig. 6) in both directions and listen for operation of gun-elevating signal motor (fig. 3). If motor runs in both directions, refer to TM 9-718A. If motor does not run, proceed with (2) through (7) below.
- (2) *Open circuit in gun-elevating signal motor* (figs. 35 and 36). Turn master relay switch to "OFF" position. Disconnect connector plug from gun-elevating signal motor (fig. 3). Using an ohmmeter, check resistance between pin "A" and pin "D." Check resistance between pin "B" and pin "C." An infinite resistance with either check indicates a faulty signal motor. Replace signal motor.
- (3) *Open circuit in harness between gun-elevating signal motor and override control box*. Turn master relay switch to "OFF" position. Disconnect connector No. 105 from override control box (fig. 3). Disconnect connector plug from gun-elevating signal motor. Using an ohmmeter, check resistance of cables in harness. An infinite resistance indicates an open cable. Replace harness.
- (4) *Open circuit in harness between pulsing relay box and override control box*. Turn master relay switch to "OFF" position. Disconnect connector No. 114 from override control

box (fig. 3). Using an ohmmeter, check resistances of cables in harness. An infinite resistance indicates an open cable. Replace harness.

- (5) *Faulty operation of override relays* (figs 29 and 31). Remove cover from override control box. Turn master relay switch and turret control switch to "ON" position. Turn loader's power safety switch to "OFF" position. Operate override lever, and check operation of override relays. Check relay contacts for good circuit connection. If operation is faulty replace override relays.
- (6) *Failure of pulsing relay* (fig. 33). Turn master relay switch and turret control switch to "ON" position. Turn loader's power safety switch to "OFF" position. Disconnect connector No. 105 from override control box (fig. 3). Displace gunner's control handle for elevating from neutral position. Using a voltmeter, check presence of voltage between pin "E" and pin "F" of electrical receptacle. If voltage is not present, replace elevating chassis assembly.
- (7) *Defective limit switch assembly*. Perform visual inspection on elevating and depressing limit switch assembly (fig. 11). Check particularly the switch control rod and positions of adjusting screws on this rod. If defective, replace limit switch assembly.

h. Turret Cannot Be Traversed in Either Direction by Gunner's Control Handle (fig. 24).

- (1) *Preliminary check*. Manual traversing crank handle (fig. 1) must be in neutral position so that locking latch will engage dump-valve micro-switch.
- (2) *Shorted dump-valve micro-switch*. Disconnect the two bell-type connectors in cables No. 150 to dump-valve micro-switch. Using an ohmmeter, check resistance through switch. An infinite resistance indicates an open switch. Replace switch.
- (3) *Open circuit in harness between gunner's control handle and override control box*. Turn master relay switch to "OFF" position. Disconnect connector No. 109 from gunner's control handle. Disconnect connector No. 102 from override control box. Using an ohmmeter, check resistance of cables in harness. An infinite resistance indicates an open cable. Replace harness.
- (4) *Open potentiometer in gunner's control handle* (figs. 24 and 28). Turn master relay switch and turret control switch to "ON" position. Turn loader's power safety switch to "OFF" position. Turn gunner's right pistol grip in one direction

until click of slew micro-switch is heard. Listen for operation of turret-traversing signal motor. If signal motor operates, replace gunner's control handle potentiometer bracket assembly.

i. Turret Cannot be Traversed in Either Direction by Commander's Control Handle (figs. 3 and 20).

- (1) *Open circuit in harness between commander's control handle and override control box.* Turn master relay switch to "OFF" position. Disconnect connector No. 107 from commander's control handle (fig. 3). Disconnect connector No. 106 from override control box. Using an ohmmeter, check resistance of cables in harness. An infinite resistance indicates an open cable. Replace harness.
- (2) *Open potentiometer in commander's control handle (figs. 20 and 23).* Turn master relay switch and turret control switch to "ON" position. Turn loader's power safety switch to "OFF" position. Turn commander's pistol grip in one direction until click of slew micro-switch in handle is heard. Listen for operation of turret-traversing signal motor. If signal motor operates, replace commander's control handle potentiometer bracket assembly.

j. 90-mm Gun Cannot be Elevated Nor Depressed by Gunner's Control Handle.

- (1) *Open circuit in harness between gunner's control handle and override control box.* Refer to f(3) above.
- (2) *Open potentiometer in gunner's control handle (figs. 24 and 28).* Turn master relay switch and turret control switch to "ON" position. Turn loader's power safety switch to "OFF" position. Turn gunner's pistol grip in one direction until click of slew micro-switch is heard. Listen for operation of gun-elevating signal motor. If signal motor operates, replace gunner's control handle potentiometer bracket assembly.

k. 90-mm Gun Cannot be Elevated Nor Depressed by Commander's Control Handle.

- (1) *Open circuit in harness between commander's control handle and override control box.* Refer to i(1) above.
- (2) *Open potentiometer in commander's control handle.* Refer to i(2) above.

l. Turret Can be Traversed in Only One Direction by Gunner's or by Commander's Control Handle.

- (1) *Open circuit in turret traversing signal motor.* Refer to f(2) above.

- (2) *Open circuit in harness between override control box and turret traversing signal motor. Refer to f(3) above.*

m. 90-mm Gun Can be Elevated, but Cannot be Depressed by Gunner's or Commander's Control Handle.

- (1) *Defective depressing limit switch assembly. Perform visual inspection of depressing limit switch (fig. 11) for correct adjustment. Disconnect connector to depressing limit switch (fig. 3). Using an ohmmeter, check resistance of cable No. 602 and switch. An infinite resistance indicates a defective switch. Replace limit switch assembly.*

- (2) *Open circuit in gun-elevating signal motor. Refer to g(2) above.*

- (3) *Open circuit in harness between gun elevating signal motor and override control box. Refer to g(3) above.*

n. 90-mm Gun Can be Depressed, but Cannot be Elevated by Gunner's or Commander's Control Handle.

- (1) *Defective elevating limit switch. Perform visual inspection on elevating limit switch (fig. 11) for correct adjustment. Disconnect connector to elevating limit switch (fig. 3). Using an ohmmeter, check resistance of cable No. 601 and switch. An infinite resistance indicates a defective switch. Replace limit switch assembly.*

- (2) *Open circuit in gun-elevating signal motor. Refer to g(2) above.*

- (3) *Open circuit in harness between gun elevating signal motor and override control box. Refer to g(3) above.*

o. Turret Can be Traversed by Gunner's Control Handle in Only One Direction.

- (1) *Open or failure to actuate one of the field micro-switches in gunner's control handle (figs. 24 and 28). Turn master relay switch to "OFF" position. Disconnect connector No. 109 from gunner's control handle (fig. 3). Turn pistol grip to the left from neutral position sufficiently to produce normal tracking action. Using an ohmmeter check resistance between pin "A" and pin "C" of electrical receptacle. Turn pistol grip to the right from neutral position sufficiently to produce normal tracking action. Check resistance between pin "A" and pin "D." An infinite resistance with either check indicates a faulty micro-switch. Replace gunner's control potentiometer bracket assembly.*

- (2) *Defective override relays (figs. 29 or 31). Remove cover from override control box. Inspect override relay contacts*

for good connections. If found defective, replace override relays.

- (3) *Open circuit in harness between gunner's control handle and override control box.* Refer to *h*(3) above.
- (4) *Open circuit in gunner's control handle.* If the trouble cannot be corrected with (1), (2), or (3) above, it is probable that an open circuit exists in the handle. Replace gunner's control potentiometer bracket assembly.

p. Turret Can be Traversed by Commander's Control Handle in Only One Direction.

- (1) *Open or failure to actuate one of the field micro-switches in commander's control handle.* Turn master relay switch to "OFF" position. Disconnect connector No. 107 from commander's control handle (fig. 3). Turn pistol grip to the left from neutral position sufficiently to produce normal tracking action. Using an ohmmeter, check resistance between pin "A" and pin "C" of electrical receptacle. Turn pistol grip to the right from neutral position sufficiently to produce normal tracking action. Check resistance between pin "A" and pin "D." An infinite resistance with either check indicates a faulty micro-switch. Replace commander's potentiometer bracket assembly.
- (2) *Defective override relays.* Refer to *o*(2) above.
- (3) *Open circuit in harness between commander's control handle and override control box.* Refer to *i*(1) above.
- (4) *Open circuit in commander's control handle* (fig. 20). If the trouble cannot be corrected with (1), (2), or (3) above, it is probable that an open circuit exists in the handle. Replace commander's potentiometer bracket assembly.

q. 90-mm Gun Cannot be Elevated With Gunner's Control Handle.

- (1) *Open or failure to actuate the field micro-switch in gunner's control handle.* Turn master relay switch to "OFF" position. Disconnect connector No. 109 from gunner's control handle (fig. 3). Turn gunner's pistol grip from neutral position sufficiently to produce normal tracking action. Using an ohmmeter, check resistance between pin "A" and pin "F." An infinite resistance indicates a faulty micro-switch. Replace gunner's potentiometer bracket assembly.
- (2) *Defective override relays.* Refer to *o*(2) above.
- (3) *Open circuit in harness between gunner's control handle and override control box.* Refer to *h*(3) above.
- (4) *Open circuit in gunner's control handle.* Refer to *o*(4) above.

r. 90-mm Gun Cannot be Depressed With Gunner's Control Handle.

- (1) *Open or failure to actuate the field micro-switch in gunner's control handle.* Turn master relay switch to "OFF" position. Disconnect connector No. 109 from gunner's control handle (fig. 3). Turn gunner's pistol grip handle from neutral position sufficiently to produce normal tracking action. Using an ohmmeter, check resistance between pin "A" and pin "G." An infinite resistance indicates a faulty micro-switch. Replace gunner's potentiometer bracket assembly.
- (2) *Defective override relays.* Refer to o(2) above.
- (3) *Open circuit in harness between gunner's control handle and override control box.* Refer to h(3) above.
- (4) *Open circuit in gunner's control handle.* Refer to o(4) above.

s. 90-mm. Gun Cannot be Elevated With Commander's Control Handle.

- (1) *Open or failure to actuate the field micro-switch in commander's control handle.* (fig. 20) Turn master relay switch to "OFF" position. Disconnect connector No. 107 from commander's control handle (fig. 3). Turn commander's pistol grip from neutral position sufficiently to produce normal tracking action. Using an ohmmeter, check resistance between pin "A" and pin "F." An infinite resistance indicates a faulty micro-switch. Replace commander's potentiometer bracket assembly.
- (2) *Defective override relay.* Refer to o(2) above.
- (3) *Open circuit in harness between commander's control handle and override control box.* Refer to i(1) above.
- (4) *Open circuit in commander's control handle.* Refer to p(4) above.

t. 90-mm. Gun Cannot be Depressed With Commander's Control Handle.

- (1) *Open or Failure to Actuate the Field Micro-Switch in Commander's Control Handle.* Turn master relay switch to "OFF" position. Disconnect connector No. 107 from commander's control handle (fig. 3). Turn commander's pistol grip from neutral position sufficiently to produce normal tracking action. Using an ohmmeter, check resistance between pin "A" and pin "G." An infinite resistance indicates a faulty micro-switch. Replace commander's potentiometer bracket assembly.
- (2) *Defective override relay.* Refer to o(2) above.
- (3) *Open circuit in harness between commander's control handle and override control box.* Refer to i(1) above.

u. Turret Goes Into Fast Tracking Speeds With Small Displacements of Both Gunner's and Commander's Control Handle. Replace pulsing relay box.

v. Turret Goes Into Fast Tracking Speeds With Small Displacements of Gunner's Control Handle But Functions Properly With Commander's Control Handle. Replace gunner's potentiometer bracket assembly.

w. Turret Goes Into Fast Tracking Speeds With Small Displacements of Commander's Control Handle But Functions Properly With Gunner's Control Handle. Replace commander's potentiometer bracket assembly.

x. Gunner's and Commander's Control Handle Must be Displaced Excessively Before Turret Starts to Traverse. Replace pulsing relay box.

y. Fast Tracking Speeds Cannot be Obtained.

(1) *Preliminary check.* Check turret voltage. It is advisable to have auxiliary engine running, or main engine running at 1,400 rpm or faster.

(2) *Faulty pulsing relay circuit.* Replace pulsing relay box.

z. Turret Will Not Go Into Slew Speed in Either or Both Directions With Gunner's Control Handle.

(1) *Preliminary check.* Remove cover from gunner's control handle. Inspect slew micro-switches for damage or improper adjustment.

(2) *Faulty slew micro-switches.* Replace gunner's potentiometer bracket assembly (fig. 26).

aa. Turret Will Not Go Into Slew Speed in Either or Both Directions With Commander's Control Handle.

(1) *Preliminary check.* Remove cover from commander's control handle. Inspect traversing slew micro-switches for damage or improper adjustments.

(2) *Faulty slew micro-switches.* Replace commander's potentiometer bracket assembly (fig. 21).

ab. Turret or Gun Goes Into Slew Suddenly When Tracking. Replace pulsing relay box.

ac. 90-mm Gun Elevates Too Far or Not Far Enough. Adjust elevating limit switch assembly (fig. 11). If gun still elevates too far or not far enough, replace limit switch assembly.

ad. 90-mm Gun Depresses Too Far or Not Far Enough. Adjust depressing limit switch assembly (fig. 11). If gun still depresses too far or not far enough, replace limit switch assembly.

ae. 90-mm Gun Will Not Go Into Slew Speed in Either or Both Directions With Gunner's Control Handle.

- (1) *Preliminary check.* Remove cover from gunner's control handle. Inspect slew micro-switches for damage or improper adjustment.
- (2) *Faulty slew micro-switches.* Replace gunner's potentiometer bracket assembly (fig. 26).

af. 90-mm Gun Will Not Go Into Slew Speed in Either or Both Directions With Commander's Control Handle.

- (1) *Preliminary check.* Remove cover from commander's control handle. Inspect elevating slew micro-switches for damage and proper adjustment.
- (2) *Faulty slew micro-switches.* Replace commander's potentiometer bracket assembly (fig. 21).

ag. 90-mm Gun Elevates or Depresses at Fast Speeds With Small Displacements of Both Gunner's and Commander's Control Handlers. Replace pulsing relay box.

ah. 90-mm Gun Elevates or Depresses at Fast Speeds With Small Displacements of Gunner's Control Handle But Functions Properly With Commander's Control Handle. Replace gunner's potentiometer bracket assembly (fig. 26).

ai. 90-mm Gun Elevates or Depresses at Fast Speeds With Small Displacements of Commander's Control Handle But Functions Properly With Gunner's Control Handle. Replace commander's potentiometer bracket assembly (fig. 21).

aj. Turret Cannot be Traversed With Gunner's Manual Traversing Control Handle.

- (1) *Open circuit in dump-valve micro-switch.* Turn master relay switch to "OFF" position. Disconnect two bell-type connectors from dump valve micro-switch. Turn manual control handle so that locking latch disengages micro-switch. Using an ohmmeter, check resistance through switch. An infinite resistance indicates an open switch. Replace micro-switch.
- (2) *Open circuit in commander's override dump-valve relay.* Turn master relay switch to "OFF" position. Disconnect connector from commander's override dump-valve relay. Using an ohmmeter, check resistance between pin "B" and pin "C" of electrical receptacle. An infinite resistance indicates an open circuit. Replace override dump-valve relay.
- (3) *Open circuit in dump-valve solenoid.* Turn master relay switch to "OFF" position. Disconnect cable No. 150 from dump-valve solenoid. Using an ohmmeter, check resistance

of solenoid. An infinite resistance indicates an open solenoid. Replace solenoid.

10. Hydraulic System

a. Trouble Shooting Before Removal of Operation.

- (1) *General.* Do not operate the turret-traversing or gun-elevating system prior to completing the procedures given in this paragraph. Refer to paragraph 7 for the purpose of these inspections.
- (2) *Inspect oil level in power pack reservoir.* The oil level should be at the groove on the dipstick or not more than $\frac{1}{2}$ inch above or below the groove.

Note. Always check the oil level at least twice since an erratic reading may be obtained on the first inspection. Use care to prevent gage from contacting the sides of the oil filler pipe while being inserted as this will coat the gage with oil and give a false reading of the oil level. Screw the filler cap down when checking the oil level.

If low, add red oil MIL-O-5606 or rust inhibited oil MIL-O-6083.

- (3) *Inspect for water in oil reservoir.* Loosen one of the drain plugs in the ends or sides of the oil reservoir and drain a small quantity of oil into a container to see if there is any water in the bottom of the oil reservoir. Retighten plug in place. Add oil to fill the oil reservoir to the proper level.
- (4) *Inspect for oil leaks.* Check for leaks caused by improper assembly or installation of the compression sleeve type fittings or leaks caused by improper contour, excessive stress or damage to the lines. Check all components for leaks, particularly at the gasket joints. Since oil will flow down the component or line, the leak is sometimes far removed from the source of the drip of oil. If necessary, tighten the fittings and nuts, tighten the screws at gasket joints or install new gaskets, when possible, without removing the components from the vehicle.
- (5) *Inspect for damaged lines.* Check all lines for possible dents or collapsed bends. Replace all damaged lines. Opening a line in the gun-elevating system automatically makes bleeding of the air from the system necessary.
- (6) *Inspect for foreign matter on ring gear.* Inspect and clean ring gear and traversing pinion gears, if necessary.
- (7) *Inspect for obstruction to turret rotation or gun movement.* Refer to TM 9-718A.

b. Trouble Shooting Before Removal and During Operation.

- (1) *General.* If the inspections in *a* above do not reveal causes of failure and the hydraulic turret-traversing and gun-elevating systems are operable; then trouble shoot it. Refer to paragraph 7 for purpose and scope of these trouble shooting procedures. In order to make a thorough test of the hydraulic turret-traversing and gun-elevating system while it is still in the turret, be sure that the batteries are charged, the main engine or the auxiliary engine is in running order, and the oil in the power pack oil reservoir is up to the proper level. Add oil (*a*(2) above)), if necessary. Before starting the power pack, unlock the gun and the turret locks and traverse the turret and operate the gun manually. Make a note of any abnormal symptoms such as excessive torque to traverse the turret, variations in torque during the cycle of the turret, evidence of backlash in the traversing mechanism, surging, hunting or drifting of the gun during elevation or depression, excessive torque requirements on the hand-operated super-charge pump or the hand-operated elevating pump, loss of pressure slowly or rapidly in the elevating system or mechanical play in the elevating cylinder piston pin bracket. Start power pack, refer to TM 9-718A. Make a note of any abnormal symptoms such as inoperative, sluggish, or intermittent gunner's or commander's control handle response, turret response not in proportion to movement of the gunner's or commander's control handle, excessive slowdown of the electric drive motor to slew turret, low slewing speed, laboring of the power pack during tracking speeds, noise in the traversing mechanism, excessive backlash between the traversing mechanism and the ring gear, surging, hunting, or drifting of the turret, "chattering" sound in the hydraulic lines, surging, hunting, or drifting of the gun, momentary drop or lift of the gun, erratic response of the gun movement, no control of the gun or the gun jumps at same spot repeatedly.

(2) *Power turret-traversing troubles.*

- (a) *Turret cannot be traversed either by power or manually.*
 1. *Outside gun traveling lock is engaged.* Be sure the gun traveling lock is disengaged (TM 9-718A).
 2. *Turret traversing lock is engaged.* Be sure the turret traversing lock is disengaged (TM 9-718A).
 3. *Obstruction to turret movement.* Be sure nothing inside or outside of the turret is preventing the turret from being traversed.

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4. *Output traversing gears and ring gear are stopped by foreign matter.* Inspect for foreign matter and clean, if necessary.
- (b) *Turret can be traversed manually but not by power.*
 1. *Circuit switches are open.* Refer to paragraph 9b.
 2. *Circuit breaker is open.* Refer to paragraph 9.
 3. *Defective electric drive motor.* Replace electric drive motor (TM 9-718A).
 4. *Defective slip ring box.* Replace slip ring box (TM 9-718A).
 5. *Battery discharged.* Recharge battery (TM 9-718A).
 6. *Poor electrical connections.* Refer to paragraph 9.
 7. *Electric drive motor gear key sheared or missing.* If electric motor operates but neither the traversing nor elevating pumps operate, remove the electric motor to see if the drive motor gear key is sheared or missing. Replace the electric drive motor gear key.
 8. *Defective gunner's control handle.* Refer to paragraph 9.
 9. *Defective commander's control handle.* Refer to paragraph 9.
 10. *Defective signal motor on turret-traversing pump control.* Refer to paragraph 9.
 11. *Traversing pump drive gear key sheared or missing.* If the electric motor operates but the traversing pump shaft does not rotate, remove the electric motor and gear case to see if the drive gear key is sheared or missing. Replace the drive gear key (fig. 44).
 12. *Power traversing bypass valve fails to close.* If the gear pump pressure is low, the differential shifting piston in the traversing mechanism may fail to actuate the plunger in the power traversing bypass valve. Check the gear pump pressure. Also check for a binding piston or plunger.
 13. *Gear pump drive gear key sheared or missing.* Replace the power pack (TM 9-718A).
- (c) *Turret-traversing pump fails to operate.*
 1. *Circuit switches are open.* Refer to paragraph 9.
 2. *Circuit breaker is open.* Refer to paragraph 9.
 3. *Defective electric drive motor.* Replace electric drive motor (TM 9-718A).
 4. *Defective slip ring box.* Replace slip ring box (TM 9-718A).
 5. *Battery discharged.* Recharged battery (TM 9-718A).

6. *Poor electrical connections.* Refer to paragraph 9.
7. *Electric drive motor gear key sheared or missing.* Refer to b(2)(b)7 above.
8. *Traversing pump drive gear key sheared or missing.* Refer to b(2)(b)11 above.
9. *Gear pump gears or ball bearings broken or frozen.* Replace the power pack (TM 9-718A).
- (d) *Turret-traversing pump operates but turret cannot be power traversed in either direction.*
 1. *Outside gun traveling lock is engaged.* Refer to b(2)(a)1 above.
 2. *Turret-traversing lock is engaged.* Refer to b(2)(a)2 above.
 3. *Obstruction to turret movement.* Refer to b(2)(a)3 above.
 4. *Output traversing gears and ring gear are stopped by foreign matter.* Refer to b(2)(a)4 above.
 5. *Defective gunner's control handle.* Refer to paragraph 9.
 6. *Defective signal motor on turret-traversing pump control.* Refer to paragraph 9.
 7. *Power traversing bypass valve fails to close.* Refer to b(2)(b)12 above.
 8. *Hydraulic motor drive gear key broken or missing.* Disconnect the hydraulic lines and remove the hydraulic motor to see if the drive gear key (fig. 68) is broken or missing. Tap the Woodruff key into the drive shaft. Slip the drive gear onto the hydraulic motor shaft with the projecting hub towards the motor and lock it in place with a cotter pin. Assemble hydraulic motor to traversing mechanism.
 9. *Traversing system relief-valve plunger sticking open, spring fatigued or broken.* If the relief-valve plunger (fig. 70) in the hydraulic motor does not seat properly and oil is free to discharge past the plunger, or if the plunger spring is fatigued or broken, sufficient pressure cannot be built up in the traverse system to turn the turret. Refit the plunger or replace the spring.
 10. *Gear-pump-relief-valve plunger sticking open, spring fatigued or broken.* If the gear-pump-relief-valve plunger (fig. 57) in the oil reservoir binds or sticks in the bushing or if the spring is fatigued or broken, there will not be sufficient pressure and volume to supercharge the system, actuate the differential shifting piston, close the power traversing bypass valve, operate the dump

- valve, actuate the neutral lock pistons and provide adequate control pressure. Refit the plunger or replace the spring.
11. *Neutral lock plunger fails to withdraw from traversing control eccentric shaft.* If the gear pump pressure is low or the neutral lock plunger binds in the cylinder, the plunger will lock the eccentric shaft in neutral position and the traversing pump will not deliver any oil in either direction. Check the gear pump pressure or refit the neutral lock plunger (fig. 46).
 12. *Slip clutch spring defective or broken.* If the spring is broken or lacks sufficient force to hold the traversing clutch gear against the clutch limit plate (fig. 45), insufficient torque will be transmitted to turn the traversing control eccentric shaft. Inspect and replace the spring.
 13. *Damaged hydraulic lines.* Inspect the hydraulic lines for leaks, dents or kinks which might impede the flow of oil. Replace as required.
 14. *Small and large control pistons sticking.* Foreign matter in either control piston cylinder, binding of either piston in its cylinder or something to impede the movement of the slide block assembly will prevent oil from being delivered to the hydraulic motor. Be sure sufficient gear pump pressure is available. Test pressure necessary to move the large control piston. If necessary, replace the power pack (TM 9-718A).
 15. *Pilot-valve-plunger sticking.* Foreign matter in the system or a bent plunger may cause erratic movement of the plunger. Remove the control lever cover and gasket and check the movement of the pilot-valve plunger (fig. 47). If necessary, clean and relap the plunger and replace the gasket and the cover.
 16. *Pilot-valve-plunger pin broken or missing.* Remove the control lever cover and gasket (fig. 47) and check to see if the control lever shoulder pin is in place.
 17. *Follow-up pin bent or stuck.* Remove the control lever cover and gasket (fig. 47) and see if the follow-up pin properly actuates the control lever when the slide block assembly moves from neutral to full stroke in each direction.
 18. *Hand-operated elevating pump system ball-type relief valve leaks, spring fatigued, or broken.* If oil delivered by the traversing pump is free to flow past the ball-type

relief valve in the traversing pump end head, no oil will be delivered to the hydraulic motor to turn the turret. Replace the power pack (TM 9-718A).

19. *Excessive leakage past traversing-pump flat valve and traversing pump shaft.* Replace the power pack (TM 9-718A).
 20. *Damaged or worn traversing pump.* Replace the power pack (TM 9-718A).
 21. *Damaged or worn hydraulic motor.* Replace the hydraulic motor (TM 9-718A).
 22. *No oil in the oil reservoir.* Refer to a(2) above. Check the oil level (TM 9-718A) and, if necessary, refill as specified in the lubrication order.
- (e) *Power traversing speed slow in either direction.*
1. *Battery charge low.* Check batteries (TM 9-718A). Recharge or replace as required.
 2. *Poor electrical connections.* Refer to paragraph 9.
 3. *Damaged hydraulic lines.* Refer to b(2)(d)(13) above.
 4. *Output traversing gears and ring gear are sluggish because of foreign matter.* Refer to b(2)(a)4 above.
 5. *Traversing system relief valve plunger sticking open, spring fatigued or broken.* Refer to b(2)(d)9 above.
 6. *Disk-type supercharge check valves leaking.* Replace the power pack (TM 9-718A).
 7. *Gear pump relief valve plunger sticking open, spring fatigued or broken.* Refer to b(2)(d)10 above.
 8. *Small and large control pistons sticking.* Refer to b(2)(d)14 above.
 9. *Rolling pistons in traversing pump are sticking.* Replace the power pack (TM 9-718A).
 10. *Rolling pistons in hydraulic motor are sticking.* Replace the hydraulic motor (TM 9-718A).
 11. *Rolling piston cylinders in traversing pump shaft are worn.* Replace the power pack (TM 9-718A).
 12. *Rolling piston cylinders in hydraulic motor are worn.* Replace the hydraulic motor (TM 9-718A).
 13. *Excessive leakage past traversing-pump flat valve and traversing-pump shaft.* Replace the power pack (TM 9-718A).
 14. *Defective electric drive motor.* Replace electric drive motor (TM 9-718A).
 15. *Defective gunner's control handle.* Refer to paragraph 9.

16. *Defective signal motor on turret-traversing-pump control.* Refer to paragraph 9.
 17. *Binding or restriction in traversing differential control mechanism.* Remove traversing-pump upper control (figs. 44, 45 and 46). Inspect, and test the control operation.
 18. *Worn traversing pump.* Replace the power pack (TM 9-718A).
 19. *Worn hydraulic motor.* Replace the hydraulic motor (TM 9-718A).
- (f) *Power traversing speed slow in one direction only.*
1. *Poor electrical connections.* Refer to paragraph 9.
 2. *One of the disk-type supercharge check valves leaking.*
Replace the power pack (TM 9-718A).
 3. *One of the ball-type accumulator system charging check valves leaking.* Replace the power pack (TM 9-718A).
 4. *Defective or improperly adjusted gunner's control handle.*
Refer to paragraph 9.
 5. *Defective or binding signal motor on turret-traversing pump control.* Refer to paragraph 9.
 6. *Binding or restriction in traversing differential control mechanism.* Refer to b(2)(e)17 above.
 7. *Small and large control pistons sticking.* Refer to b(2)(d)14 above.
 8. *Pilot valve plunger sticking.* Refer to b(2)(d)15 above.
- (g) *Turret can be power traversed in one direction only.*
1. *Poor electrical connections.* Refer to paragraph 9.
 2. *One of the disk-type supercharge check valves leaking.*
Replace the power pack (TM 9-718A).
 3. *One of the ball-type accumulator system charging check valves leaking.* Replace the power pack (TM 9-718A).
 4. *Defective or improperly adjusted gunner's control handle.*
Refer to paragraph 9.
 5. *Defective signal motor on turret-traversing pump control.*
Refer to paragraph 9.
 6. *Small and large control pistons sticking.* Refer to b(2)(d)14 above.
 7. *Slide block assembly sticking.* Foreign matter in between the rollers and cages, improper installation of the shims (if any) between the slide block roller plates and the pump case, or scored surfaces on the slide block assembly or roller plates may impede the slide block assembly movement. Replace the power pack (TM 9-718A).

(h) *Turret creeps.*

1. *Gunner's control handle not centered.* Refer to paragraph 9.
2. *Feedback mechanism disconnected.* If the feedback mechanism to the power-pack is disconnected, the differential control feature is inactive and the turret may tend to creep in one direction. The creep can be reduced to a minimum by adjusting the socket-head set screw in the control lever which contacts the follow-up pin (fig. 47). Adjust the screw until the pilot valve and the slide block assembly are properly centered.

(i) *Turret surges while traversing; speed control unsteady.*

1. *Defective gunner's control handle.* Refer to paragraph 9.
2. *Defective signal motor on turret-traversing pump control.* Refer to paragraph 9. Listen for variations in sound (variations in speed) of the signal motor at various settings of the gunner's control handle. Listen for a "skip" or "overrunning" effect while control handle is fixed. Traverse turret to observe if surges are similar at low and high speeds, and if surge appears at inconsistent intervals or if turret speed intermittently increases to almost the slow rate. If so, remove the signal motor from the control and observe the response of the motor at various rates in each direction. Listen for occasional "galloping" of the signal motor. Replace signal motor assembly.
3. *Improper wind-up of traverse pinion cocking spring.* Refer to paragraph 49.
4. *Binding of traversing mechanism and azimuth indicator on ring gear.* Check for "bottoming" of the pinion gears and azimuth drive gear and shim the components, if necessary. Refer to paragraph 11.
5. *Backlash or binding between feedback gears and ring gear.* Check for "bottoming" of the feedback gears. Adjust or replace gears. Refer to paragraph 11.
6. *Backlash or binding in feedback shafts and universal joints.* Check for scoring caused by feedback shaft end connectors contacting feedback gear mounting plate. Adjust for proper clearance. Grip feedback mechanism firmly and feel for play. As little as 0.002 inch play may cause erratic operation. Mounting screws may be loose or broken.
7. *Improper assembly or mounting of feedback mechanism.* This may cause a variation in the velocity of the feedback

- to the power pack control and initiate demands for variable speed without movement of the gunner's control handle. Check and reset.
8. *Improper setting of feedback shafts to accommodate universal joint action.* In most cases, binding caused by vertical movement due to the universal joint action can be remedied by loosening the lower shaft connector and determining the amount of vertical movement available and then reconnecting the shaft so as to "split the difference", putting half of the movement on each end of the movement can be both ways in a perpendicular plane. Avoid excessive perpendicular binding action on the auxiliary input feedback shaft in the power pack control.
9. *Backlash, end play or binding of gears or shafts in the traversing control mechanism.* Refer to b(2)(c)17 above. Remove the signal motor assembly. With the power pack in operation check for binding or backlash by rotating the worm shaft gear (fig. 42) with the fingers. Check also by disconnecting the auxiliary input feedback shaft (fig. 44) and blocking the rotation of this shaft. Rotate the worm shaft gear and check to see if a movement involving more than five teeth on the worm shaft gear are necessary to change from clockwise to counterclockwise turret rotation. If more than five teeth, consider this excessive backlash in the control gear train. Eliminate end play in the worm shaft (fig. 42) by shimming behind the inner ball bearing. Do not bind the worm shaft. Check to see if the worm shaft is bent. Handle the worm shaft with care as it is easily bent. If the traversing control differential (fig. 43) is sluggish, binds or has excessive backlash (excessive being more than one tooth of play measured at the differential input gear), replace with a new traversing control differential. Check for abnormal play in the Woodruff keys.
10. *Perceptible slip or lack of torque between traversing clutch gear and clutch limit plate.* With the signal motor in place, check the torque required to slip the traversing clutch gear (fig. 45) on the clutch limit plate. Disconnect the feedback mechanism and apply torque to the auxiliary input feedback shaft (fig. 44). Check for smooth even "drag" with a minimum of one and one-half 16-inch torque and a maximum of four 16-inch torque. If torque is low or erratic, remove the travers-

ing control upper case assembly, clutch limit plate and traversing clutch gear. If possible, improve the cone contact area on the clutch limit plate and in the traversing clutch gear. Check the clutch spring and replace, if necessary. Recheck assembly to see if the proper torque is obtained.

11. *Pilot valve plunger sticking.* Refer to *b(2)(d)15* above. Avoid excessive force on control lever or pilot valve plunger because these parts are easily damaged.
12. *Follow-up pin bent or stuck.* Refer to *b(2)(d)17* above.
13. *Obstruction to turret movement.* Refer to *b(2)(a)3* above.
14. *Traversing system relief valve setting is low.* Loosen the relief valve cap on the hydraulic traversing motor about one turn. If operation becomes more erratic, shut off the power pack, remove the relief valve cap and insert shims into the cap at the rate of about 0.005-inch thick each trial, until turret operation is improved. Over-shimming will cause turret to whip back when gunner's power control is released at slewing speed. If the relief valve plunger is removed for inspection or replacement be sure in assembly to insert the small diameter first.
15. *Low oil level in oil reservoir.* Refer to *a(2)* above. Spongy response to gunner's power control or whip action when gunner's power control is released may be due to a low oil level, allowing air to be drawn into the system. Disconnect the drain line from the hydraulic motor to see if oil appears frothy or lighter than the oil should normally appear. Check the oil level in the oil reservoir. Look for leaks which might account for the low oil level.
16. *Air in the traversing system.* Excessive air in the system dampens the dither pump action, causes a spongy response or whip action to gunner's power control. When starting a new or idle unit, loosen one of the nuts on the compression tube fittings in ports 3 or 4 to bleed the air out of the traversing system. Tighten nut when solid oil appears. Bleed air from system several times to assure having a solid column of oil in the turret-traversing and gun-elevating systems. Refer to TM 9-718A for bleeding air from the system.
17. *Restrictions in turret bearing.* If the surge is prevalent at specific points in the turret travel, check for foreign

matter in the turret bearing, binding of turret and bearing at various points and defective turret bearing. Refer to paragraph 11.

(j) *Turret jumps or drifts when starting power pack.*

1. *Traversing pump slide block assembly may not be centered.* To adjust the slide block assembly position, remove the follow-up pin spring cap (fig. 47), and cap gasket from the control lever cover. Loosen the small socket-head set screw in the control lever and adjust the large socket-head set screw contacting the follow-up pin until the turret does not jump or drift when power pack is started. Usually, this adjustment is not too critical. The traversing pump will seek its neutral position if the adjustment is not off too much. When considerable adjustment may be necessary, the traversing control upper case assembly should be removed. Hold the clutch limit plate so that no turret motion is obtained. Then adjust the large socket-head set screw above the follow-up pin to bring the clutch limit plate at right angles with the side of the traversing control lower case. Lock the large socket-head set screw in place with the small socket-head set screw in the control lever and replace the cap gasket and cap.

2. *Neutral dead spot on gunner's control handle may not be centered.* Adjust the gunner's control handle to provide equal dead spot travel on each side of the spring centered neutral position. Refer to paragraph 9.

(k) *Turret traverses when power pack is started and gunner's control handle is stationary.*

1. *Hydraulic lines to traversing motor are reversed.* Check the hydraulic lines leading from the traversing pump to the bypass valve and the hydraulic motor. Port 3 on the oil reservoir should be connected to the bypass valve and to port 2 on the motor. Port 4 on the oil reservoir should be connected to the bypass valve and to port 1 on the motor. Change lines, if necessary (TM 9-718A).

2. *Feedback mechanism is loose, disconnected, or broken.* Carefully check the feedback gears, shafts, universal joints and connection to the auxiliary input feedback shaft. Tighten or replace parts.

3. *Pilot valve plunger is sticking.* Refer to b(2)(d)15 above. If necessary, lap the pilot valve plunger or wipe

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down the burs at the oil grooves with crocus cloth. If the pilot valve plunger is bent as little as 0.001 inch it will not move freely in the pilot valve plunger bushing.

4. *Clutch limit plate slips in the traversing clutch gear.* Refer to *b(2)(i)10* above. If the torque is low, the force of the pilot valve spring will slip the clutch limit plate and put the traversing pump on stroke.

(l) Abnormal noise in the traversing pump.

1. *Low oil level in the oil reservoir.* Refer to *a(2)* above.
2. *Loose gear pump suction line connection.* If the compression tube fittings and the hydraulic line connecting port 8 on the drive gear case with port 13 in the oil reservoir leak, air may be drawn into the system. Check nuts and fittings for tightness and tube for kinks or cracks.
3. *Worn traversing pump bearings.* Replace the power pack (TM 9-718A).
4. *Sticking rolling pistons.* Replace the power pack (TM 9-718A).
5. *Worn or broken gear pump gears.* Replace the power pack (TM 9-718A).

(m) Abnormal noise in the hydraulic motor.

1. *Air in the system.* Refer to *b(2)(i)16* above.
2. *Worn hydraulic motor bearings.* Replace the hydraulic motor (TM 9-718A).
3. *Sticking rolling pistons.* Replace the hydraulic motor (TM 9-718A).
4. *Traversing system relief valve setting is low.* Refer to *b(2)(d)9* above. This valve is for overload protection and should not open during normal operation. If the groove in the relief valve plunger is too deep or the fit in the bushings too loose, chatter or vibration will be apparent.

(3) Power gun-elevating or depressing troubles.

(a) Gun cannot be elevated or depressed by power or manually.

1. *Outside gun traveling lock is engaged.* Refer to *b(2)(a)1* above.
2. *Obstruction to gun movement.* Be sure nothing inside or outside of the turret is preventing the gun from being elevated or depressed. Refer to *b(2)(a)3* above.

(b) Gun can be elevated and depressed manually but not by power.

1. *Circuit switches are open.* Refer to paragraph 9.

2. *Circuit breaker is open.* Refer to paragraph 9.
 3. *Defective electric drive motor.* Replace electric drive motor (TM 9-718A).
 4. *Defective slip ring box.* Replace slip ring box (TM 9-718A).
 5. *Battery discharged.* Recharge battery (TM 9-718A).
 6. *Poor electrical connections.* Refer to paragraph 9.
 7. *Electric drive motor gear key sheared or missing.* Refer to b(2)(b)7 above.
 8. *Defective gunner's power control handle.* Refer to paragraph 9.
 9. *Defective commander's power control handle.* Refer to paragraph 9.
 10. *Defective signal motor on gun-elevating pump control.* Refer to paragraph 9.
 11. *Elevating pump drive gear key sheared or missing.* If the electric drive motor operates but the elevating pump shaft does not rotate, remove the electric drive motor and gear case to inspect for a sheared or missing drive gear key (fig. 54).
 12. *Supercharge shut-off valve closed; selector valve is in manual operating position.* Unless the supercharge shut-off valve in the gear pump pressure hydraulic line to the selector valve is open the selector valve will not shift to power elevating position. Open valve and wait a few seconds for selector valve plungers to shift.
 13. *Gear pump drive gear key sheared or missing.* Replace the power pack (TM 9-718A).
- (c) *Gun elevating pump fails to operate.*
1. *Circuit switches are open.* Refer to paragraph 9.
 2. *Circuit breaker is open.* Refer to paragraph 9.
 3. *Defective electric drive motor.* Replace electric drive motor (TM 9-718A).
 4. *Defective slip ring box.* Replace slip ring box (TM 9-718A).
 5. *Battery discharged.* Recharge battery (TM 9-718A).
 6. *Poor electrical connections.* Refer to paragraph 9.
 7. *Electric drive motor gear key sheared or missing.* Refer to b(2)(b)7 above.
 8. *Elevating pump drive gear key sheared or missing.* Refer to b(3)(b)11 above.
- (d) *Gun-elevating pump operates but gun cannot be elevated or depressed.*

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1. *Outside gun traveling lock is engaged.* Refer to b(2)(a)1.
2. *Obstruction to gun movement.* Refer to b(2)(a)3 above.
3. *Defective gunner's power control handle.* Refer to paragraph 9.
4. *Defective commander's power control handle.* Refer to paragraph 9.
5. *Defective signal motor on gun-elevating pump control.* Refer to paragraph 9.
6. *Supercharge shut-off valve closed; selector valve is in manual operating position.* Refer to b(3)(b)12 above.
7. *Gun-elevating system relief valve plunger sticking open; spring fatigued or broken.* If the relief valve in the elevating pump end head does not seat properly and oil is free to discharge past the plunger; or if the plunger spring is fatigued or broken, sufficient pressure cannot be built up in the elevating system to elevate or depress the gun. Replace the power pack (TM 9-718A).
8. *Gear pump relief valve plunger sticking open spring fatigued or broken.* Refer to b(2)(d)10 above. If the gear pump relief valve plunger (fig. 57) in the oil reservoir binds or sticks in the bushing or if the spring is fatigued or broken, there will not be sufficient pressure and volume to supercharge the system, actuate the plungers in the selector valve, operate the neutral lock piston or provide adequate control pressure. Refit the plunger or replace the spring.
9. *Neutral lock plunger fails to withdraw from the elevating control eccentric shaft.* If the gear pump pressure is low or the neutral lock plunger (fig. 53) binds in the cylinder, the plunger will lock the eccentric shaft in neutral position and the elevating pump will not deliver any oil in either direction. Check the gear pump pressure or refit the neutral lock plunger.
10. *Slip clutch spring defective or broken.* If the spring is broken or lacks sufficient force to hold the elevating clutch gear (fig. 45) against the clutch limit plate, insufficient torque will be transmitted to turn the elevating control eccentric shaft. Inspect and replace the spring (par. 11c(2)(b)).
11. *Damaged hydraulic lines.* Refer to b(2)(d)13 above.
12. *Small and large control pistons sticking.* Foreign matter in either control piston cylinder, binding of either piston in its cylinder or something to impede the move-

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ment of the slide block assembly will prevent oil from being delivered to the selector valve and elevating cylinder. Be sure sufficient gear pump pressure is available. Test the pressure necessary to move the large control piston. If necessary, replace the power pack (TM 9-718A).

13. *Pilot valve plunger sticking.* Foreign matter in the system or a bent plunger may cause erratic movement of plunger. Remove the control lever cover and gasket and check the movement of the pilot valve plunger (fig. 47). If necessary, clean and relap the plunger and replace the gasket and the cover.
14. *Pilot valve plunger pin broken or missing.* Remove the control lever cover and gasket (fig. 47) and check to see if the control lever shoulder pin is in place.
15. *Follow-up pin bent or stuck.* Remove the control lever cover and gasket (fig. 47) and see if the follow-up pin properly actuates the control lever when the slide block assembly moves from neutral to full stroke in each direction.
16. *Excessive leakage past elevating pump flat valve and elevating pump shaft.* Replace the power pack (TM 9-718A).
17. *Damaged or worn elevating pump.* Replace the power pack (TM 9-718A).
18. *Damaged or worn gun-elevating cylinder.* Refer to paragraph 12.
19. *No oil in the oil reservoir.* Refer to a(2) above.
- (c) *Power gun-elevating and depressing slow in either direction.*
 1. *Battery charge low.* Recharge battery (TM 9-718A).
 2. *Poor electrical connections.* Refer to paragraph 9.
 3. *Damaged hydraulic lines.* Refer to b(2)(d)13 above.
 4. *Elevating system relief valve plunger sticking open; spring fatigued or broken.* Refer to b(3)(d)7 above.
 5. *Disk-type supercharge check valves leaking.* Replace the power pack (TM 9-718A).
 6. *Gear pump relief valve plunger sticking open; spring fatigued or broken.* Refer to b(2)(d)10 above.
 7. *Small and large control pistons sticking.* Refer to b(3)(d)12 above.
 8. *Rolling pistons in elevating pump are sticking.* Replace the power pack (TM 9-718A).

9. *Rolling piston cylinders in elevating pump shaft are worn.* Replace the power pack (TM 9-718A).
10. *Elevating cylinder is worn.* Replace the elevating cylinder (TM 9-718A).
11. *Excessive leakage past elevating pump flat valve and elevating pump shaft.* Replace the power pack (TM 9-718A).
12. *Excessive slip past selector valve plungers.* Replace the selector valve (TM 9-718A).
13. *Restricted flow through selector valve.* Replace the selector valve (TM 9-718A).
14. *Defective electric drive motor.* Replace electric drive motor (TM 9-718A).
15. *Defective gunner's control handle.* Refer to paragraph 9.
16. *Defective signal motor on gun-elevating pump control.* Refer to paragraph 9.
17. *Binding or restriction in gun-elevating differential control mechanism.* Remove elevating pump upper control mechanism. Disassemble, inspect, and test the control operation. Replace the upper control mechanism or the power pack (TM 9-718A).
18. *Worn gun-elevating pump.* Replace the power pack (TM 9-718A).
- (f) *Either power gun-elevating or depressing speed slow.*
 1. *Poor electrical connections.* Refer to paragraph 9.
 2. *One of the disk-type supercharge check valves leaking.* Replace the power pack (TM 9-718A).
 3. *Defective or improperly adjusted gunner's power control handle.* Refer to paragraph 9.
 4. *Defective or binding signal motor on gun-elevating pump control.* Refer to paragraph 9.
 5. *Binding or restriction in elevating differential control mechanism.* Remove elevating pump upper control mechanism. Disassemble, inspect, and test control operation. Replace the upper control mechanism or the power pack (TM 9-718A).
 6. *Small and large control pistons sticking.* Refer to b(3)(d)12 above.
 7. *Pilot valve plunger sticking.* Refer to b(3)(d)13 above.
- (g) *Either power elevation or depression, but not both.*
 1. *Poor electrical connections.* Refer to paragraph 9.

2. *One of the disk-type supercharge check valves leaking.*
Replace the power pack (TM 9-718A).
 3. *Defective or improperly adjusted gunner's control handle.*
Refer to paragraph 9.
 4. *Defective signal motor on gun-elevating pump control.*
Refer to paragraph 9.
 5. *Small or large control piston sticking.* Refer to b(3)(d)12 above.
 6. *Slide block assembly sticking.* Refer to b(2)(g)7 above.
- (h) *Gun creeps.*
1. *Gunner's control handle not centered.* Adjust control or dead spot resistor for positive neutral position when the gunner's power control is released. Refer to paragraph 9.
 2. *Feedback mechanism disconnected.* If the feedback mechanism (fig. 52) to the power pack is disconnected the differential control feature is inactive and the gun may tend to creep in one direction. The creep can be reduced to a minimum by adjusting the socket-head set screw in the control lever which contacts the follow-up pin (fig. 47). Adjust the screw until the pilot valve and the slide block assembly are properly centered.
- (i) *Gun surges (hunts); speed control unsteady.*
1. *Defective gunner's control handle.* Refer to paragraph 9.
 2. *Defective signal motor on gun-elevating pump control.*
Refer to paragraph 9.
 3. *Play in elevating cylinder piston pin bracket.* Listen for a sharp, heavy metallic knock when gun drops from power to manual operation or repeated heavy knocking sound while traveling over moderately rough terrain with gun elevated but not locked. Visually check piston pin and bracket when gun shifts from power to manual elevation and when tank is in motion. Any motion that is visible is too much. Remove elevating bracket and improve the fit of the pin for zero backlash. A slight bind at this point will have no adverse effect.
 4. *Mechanical interference with feedback cable, cable guide pulley or cable pulley assembly.* When a regular, even jump occurs at the same spot repeatedly; noisy tracking of the cable; chattering noise from the pulley assembly during gun movement or a "snapping" sound as the cable leaves the pulley assembly, visually check the pathway of the cable at all ranges of elevation and depression.

Inspect the groove in the pulley assembly (fig. 52) for imbedded foreign material, check the lay of the cable in the groove of the pulley assembly and test for sufficient or insufficient wind-up. Eliminate all interferences with the cable by repositioning components (usually the accumulator) causing interference. Clean out the groove in the pulley assembly. Position the cable so that it lays properly in the groove in the pulley assembly. Add or remove tension as necessary for proper operation of the gun. Check for sufficient clearance between the pulley assembly and the control lever cover.

5. *Backlash, end play or binding of gears or shafts in the elevating control mechanism.* Refer to b(2)(i)9 above. Remove the signal motor (fig. 42). With the power pack in operation, check for binding or backlash by rotating the worm shaft gear with the finger tip. Check also by carefully disconnecting the feedback cable and immobilizing the pulley assembly (fig. 52). (Retain the feedback shaft spring tension by placing a small piece of steel between the pulley assembly hexagon flat and the control lever cover. Rotate the worm shaft gear and check to see if a movement involving more than four teeth on the worm shaft gear is necessary to change from gun-elevating to depression.

Note. Every caution against injury or damage to the gun-elevating mechanism should be applied when making this test. Hand elevate the gun to approximately the mid point of travel. Start the power pack. Do not permit the gun to power-elevate or depress to the maximum point of travel. If gun continues to travel uncontrolled toward maximum point of elevation or depression, quickly shut off the power, wait until the selector valve shunts to manual elevation position and manually elevate or depress the gun to approximately the mid point of travel.

If more than four teeth of movement is necessary, consider this excessive backlash in the control gear train. Replace the upper control mechanism. Eliminate end play in the worm shaft by shimming behind the inner ball bearing (fig. 42). Do not bind the worm shaft. Check to see if the worm shaft is bent. If the elevating or superelevating differentials (fig. 43) are sluggish, bind or have excessive backlash (excessive being more than one half tooth of play measured at the differential input gears), replace with new elevating or superelevating differentials. Check for abnormal play in the Woodruff

keys. If necessary, replace the power pack (TM 9-718A).

6. *Perceptible slip or lack of torque between elevating clutch gear and clutch limit plate.* With the signal motor in place, check the torque required to slip the elevating clutch gear on the clutch limit plate (fig. 45). Remove the elevating control upper case cover (fig. 51) or the super-elevating mechanism and apply torque to the super-elevating input gear. Check for a smooth even "drag" with a minimum of two-tenths and a maximum of one and six-tenths inch pounds torque. If torque is low or erratic, remove the elevating control upper case assembly, clutch limit plate and elevating clutch gear. If possible, improve the cone contact area on the clutch limit plate and in the elevating clutch gear. Check the clutch spring and replace, if necessary. Check assembly to see if the proper torque is obtained. If necessary, replace the power pack (TM 9-718A).
 7. *Pilot valve plunger sticking.* Refer to *b(3)(d)13* above. Avoid excessive force on the control lever or the pilot valve plunger because these parts are easily damaged.
 8. *Follow-up pin bent or struck.* Refer to *b(3)(d)15* above.
 9. *Obstruction to gun movement.* Refer to *b(2)(a)3* above.
 10. *Elevating system relief valve setting is low.* Refer to *b(3)(d)7* above.
 11. *Low oil level in oil reservoir.* Refer to *a(2)* above. Spongy response to gunner's control handle or whip action when gunner's control handle is released may be due to a low oil level allowing air to be drawn into the system. Check the oil level in the oil reservoir (TM 9-718A).
 12. *Air in the elevating system.* Excessive air in the system causes a spongy response or whip action to gunner's control handle. When starting a new or idle unit, bleed air from the system (TM 9-718A).
- (j) *Gun jumps or drifts when starting power pack.*
1. *Elevating pump slide block assembly may not be centered.* To adjust the slide block assembly position, remove the follow-up pin spring cap and cap gasket from the control lever cover (fig. 47). Loosen the small socket head set screw in the control lever and adjust the large socket head set screw contacting the follow-up pin until the gun does not jump or drift when power pack is started.

Usually, this adjustment is not too critical. The elevating pump will seek its neutral position if the adjustment is not off too much. When considerable adjustment may be necessary, the elevating control upper case assembly should be removed. Hold the clutch limit plate so that no gun motion is obtained. Then adjust the large socket head set screw above the follow-up pin to bring the clutch limit plate at right angles with the side of the elevating control lower case. Lock the large socket head set screw in place with the small socket head set screw in the control lever and replace the cap gasket and cap.

2. *Neutral dead spot on gunner's control handle may not be centered.* Adjust the gunner's control handle to provide equal dead spot travel on each side of the spring centered neutral position. Refer to paragraph 9.
- (k) *Gun elevates or depresses when power pack is started and gunner's control is stationary.*
1. *Hydraulic lines to elevating selector valve are reversed.* Check the hydraulic lines leading from the elevating pump to the selector valve. Port 1 on the oil reservoir should be connected to the selector valve port which directs oil to the upper end of the gun-elevating cylinder. Port 2 on the oil reservoir should be connected to the selector valve port which directs oil to the lower end of the gun-elevating cylinder. Change lines, if necessary (TM 9-718A).
 2. *Mechanical interference with feed-back cable, cable guide pulley or cable pulley assembly.* Refer to b(3)(i)4 above.
 3. *Pilot valve plunger is sticking.* Refer to b(3)(d)13 above.
 4. *Clutch limit plate slips in the elevating clutch gear.* Refer to b(3)(i)6 above.
- (l) *Abnormal noise in the elevating pump.*
1. *Low oil level in the oil reservoir.* Refer to a(2) above.
 2. *Loose gear pump line connection.* Refer to b(2)(l)2 above.
 3. *Worn elevating pump bearings.* Replace the power pack (TM 9-718A).
 4. *Sticking rolling pistons.* Replace the power pack (TM 9-718A).
 5. *Elevating system relief valve setting is low.* Refer to b(3)(d)7 above.
- (m) *Gun drops steadily after shutting off power pack.* Defective accumulator system ball-type check valve in transversing pump. Block off port 5 at the tee near the accumulator

and pressurize the manual elevation system with the hand-pump. If pressure is maintained in the system, reconnect the hydraulic line to the tee near the accumulator but put a pressure gage in the supercharge circuit, pressurize the manual or the elevation system and watch the pressure gage. If a reading is obtained, oil is leaking past one of the accumulator system ball-type check valves in the traversing pump. Replace the power pack (TM 9-718A).

11. Hand Drive, Traversing Mechanism, and Shifting Mechanism

a. General. Turret malfunction due to traversing mechanism when definitely established, should prompt immediate examination and repair inside the turret when possible. The unit assembly is in a relatively restricted working area of the turret and associated electric and hydraulic components must be removed before the traversing mechanism and hand drive assembly is completely accessible for repair. Complete knowledge of component functional duties and the principles of operation should be thoroughly understood so that time and labor will not be spent unnecessarily in disassembly. Simple inspection checking procedures should be observed. Turret reactions will correctly determine the trouble source. It is expedient to effort and time for the trouble shooter to perform tests inside the turret. After the trouble source has been determined and associated components have been removed, release the left vertical mounting bolt (fig. 72), and the three half-inch horizontal bolts through the main housing's mounting radius (fig. 72). This allows the hand drive, traversing mechanism, and shifting mechanism to be swung free of the turret ring gear on the right vertical mounting bolt in a position for complete servicing. Component operational failure will be confined primarily within the area of six subassemblies of the unit assembly. In sequence of accessibility and simplicity of repair they are: the no-back lock assembly, the power-traversing-bypass valve, the piston shifting assembly, the differential assembly, the slip clutch assembly, and the motor drive "anti-lash" assembly.

b. Operating Characteristics.

- (1) *Hand drive.* Idler gears connected to a spring-loaded clutch mechanism (par. 47) driven from a traverse crank handle through a no-back lock (par. 46) connect through a differential to the traversing mechanism for manual operation.
- (2) *Traversing mechanism.* Two main shaft assemblies with traversing pinion gears are connected through identical plan-

etary reduction gear systems to a common drive. Coupling to the common drive gear is accomplished by a gear assembly which is spring-loaded to eliminate the lash between all gears of both main shaft assemblies (fig. 75).

- (3) *Shifting mechanism.* A differential (par. 50) connects or disconnects the traversing mechanism and hand drive for manual or power operation, using hydraulic power to operate a differential shifting piston assembly (par. 48). A power-traversing-bypass valve (par. 51) controls the hydraulic motor allowing it to function only during power operation.

c. *Manual Traversing Troubles.*

- (1) *Manual operation not possible. Handle will not turn.*
- (a) *Gun travel lock is engaged.* Release gun from travel lock (TM 9-718A).
 - (b) *Turret lock is engaged.* Release turret lock (TM 9-718A).
 - (c) *Foreign matter at traversing pinion gears.* Inspect and clean if necessary.
 - (d) *Foreign matter at turret ring gear.* Inspect and clean if necessary (TM 9-718A).
 - (e) *No-back lock bar mutilated and binding to lock ring.* Remove idler gear housing inspection plate (M, fig. 72) and check for movement of no-back bevel gear. Remove and inspect no-back lock. If necessary remove and replace no-back lock.
 - (f) *No-back lock assembled incorrectly.* Lock bar and spring may have been inverted so that drive and driven direction of lock action is reversed. Remove no-back lock in housing assembly. Check both ends to see if rotation is possible from either. Reassemble correctly (par. 46).
 - (g) *Frozen shaft in hydraulic motor.* Remove motor and attempt manual drive operation. Refer to paragraph 10.
 - (h) *Lever in manual hand crank fails to clear safety lock slot of hand crank housing.* Compress handle grip and visually inspect clearance and movement of lever. Remove crank arm and repair lever operating linkage.
 - (i) *Retaining rings at motor drive gear shaft loose. Gear binding in housing.* Remove hydraulic motor and check visually through upper adapter's pilot diameter (EE, fig. 71). Motor drive gear must not bind on socket head screws of lower adapter housing. If necessary, remove upper adapter housing and replace retaining ring.
 - (j) *Pin from differential assembly has lost a retaining ring, and is causing interference in the motor support housing.*

Remove the hydraulic motor and bracket supporting the hand elevating pump and electrical control equipment. Follow procedure outlined in *a.* above. Remove complete hand drive and switching mechanism. Inspect and repair or replace differential if necessary.

- (k) *Foreign matter at internal gear meshes.* With the mechanism free of the turret ring gear and the traverse and hand drive mechanisms separated as in (j) above, rotate each assembly individually. Continue disassembly of the defective assembly. Inspect gears and bearings until the source of trouble is found. Repair, install, or replace defective components damaged by foreign matter ((3) (i) below).
 - (l) *Damage turret ring bearing retainers.* If turret cannot be rotated after traversing pinion gears have been removed from mesh with the turret ring gear and associate turret equipment is not preventing turret motion, major repair of the turret ring gear is indicated.
- (2) *Manual traverse not possible. Manual traverse crank handle rotates.*
- (a) *Sheared key at no-back driven bearing.* Remove inspection plate at bottom of idler gear housing (M, fig. 72). Inspect for output movement from no-back bevel gear when manual traverse crank handle is rotated. Remove, repair, or replace key and no-back bevel gear assembly if necessary. Refer to (4) (b).
 - (b) *Clutch spring weak or broken.* Insufficient force to maintain contact pressure of mating conic sections will cause slippage resulting in no output from clutch assembly. Remove cover cap over manual drive gear on idler gear housing cover. Inspect for movement of manual drive gear shaft when manual traverse handle is rotated. Increase spring pressure or replace and adjust load of clutch assembly until slippage starts when 650 lb-in. torque is applied (par. 47).
 - (c) *Differential gear shift-shaft fails to return to the manual position.* Tap piston housing assembly with power "ON". Unit may continue to operate in power while switching to and from manual drive operation. Remove power-traversing-bypass valve. Test manual return piston spring ($103 \pm 4\frac{1}{2}$ pounds at working height of $2\frac{7}{32}$ inch). Operate piston by hand effort. Remove piston. Shift gear must move freely to or from manual position. Remove

differential. If necessary, repair spline of gear shift-shaft or bushings. Replace differential if necessary. Check timing of differential (par. 48).

- (d) *Piston sticking or frozen in power traverse position.* Remove power-traversing-bypass valve. Operate the piston manually. Remove and inspect for vertical interference, wear lines, or foreign matter which will interfere with free piston movement. Repair or replace if necessary (par. 50).
- (3) *Manual traversing effort high.*
 - (a) *Foreign matter at traversing pinion gears (E, fig. 72).* Visually inspect for foreign matter and clean if required.
 - (b) *Improper lubrication.* Lubricate turret race bearings and ring gear (TM 9-718A).
 - (c) *Damaged turret race bearing turret ring gear or traverse pinion gears.* Inspect for mutilation. Replace defective parts. Traverse pinions may be changed in turret by traversing turret to a position where traversing mechanism pinion gears are accessible from the driver's or assistant driver's seat. Lock turret. Wind traverse handle crank in a direction to relieve anti-lash torque at the desired traverse pinion gear (par. 49). Remove bearing cap assembly and replace defective pinion gear (par. 35).
 - (d) *Hydraulic motor torque is high.* Remove hydraulic motor. Try manual drive torque. If free, inspect hydraulic motor (par. 10).
 - (e) *Spring tension high in no-back lock.* Excessive tension of spring of no-back lock results in high manual driving effort. Lock bar and lock ring friction becomes too great. Remove no-back lock and adjust or replace. Torque test for 3 to 5 lb-in. drive effort at no-back lock drive bearing. Torque test no-back driven bearing (par. 46).
 - (f) *Hand-drive bevel gear meshes incorrectly.* Improper amount of shim thickness at mounting surfaces may cause a binding condition at either bevel gear mesh in the hand drive resulting in exhausting manual drive effort. The packing ring between no-back and idler gear housing may not be seated properly. Relocate packing ring and add shims where necessary.
 - (g) *Lugs of manual drive gear lock washer is binding at bearing cover cap.* Remove cover cap (DD, fig. 71). Inspect for interference. Bend all lugs of lock washer flush with nut.

- (h) *Antilash torque is high.* Check and reduce backlash torque in traverse mechanism to correct value (par. 49). Before proceeding to change antilash torque, test torque at several different traverse positions of the turret.
- (i) *Defective bearing in traversing mechanism or hand drive.* Isolate by subassemblies (a. above). Replace bearing.
- (4) *Erratic turret motion during manual operation.*
 - (a) *Clutch may be slipping due to a weak or broken spring.* Remove bearing cover and observe motion of manual drive gear. Remove lower inspection plate (M, fig. 72) and inspect or adjust spring tension.
 - (b) *Key may be sheared at no-back bevel gear.* Remove lower inspection plate and inspect output at bevel gear (L, fig. 73) by rotating manual traverse crank handle. Remove no-back lock. Remove and replace necessary parts.
 - (c) *Pin in differential assembly may have lost retaining ring. Pin binds temporarily in motor support housing.* Remove hand drive and switching mechanism. Inspect differential. Repair or replace faulty parts (par. 50).
 - (d) *Spring in antilash assembly broken or loose.* Test traverse pinion gear torque (par. 49). Remove hand drive and shifting mechanism. Repair or replace defective components after removing the motor support housing. Reset torque.
- (5) *Turret continues to rotate after manual driving effort is stopped.*
 - (a) *Spring broken or weak in clutch assembly.* Remove cover cap at manual drive gear and lower inspection plate. Operate turret manually. Increase spring torque load. Replace if necessary (par. 47).
 - (b) *Pin sheared or missing at no-back lock ring and housing.* Lock ring rotates with lock bar and driven bearing (fig. 74). Turret momentum is not resisted. Disassemble, inspect, and replace when necessary.
 - (c) *No-back lock ring and bar is worn.* No "lock" or binding action can occur. Disassemble, inspect, and replace no-back lock (par. 46).
 - (d) *Spring in no-back mechanism is broken or weak.* Lock bar sticks to driven bearing and "lock" action is erratic or fails completely. Remove, inspect, and replace. Test no-back driving torque and lock action ((3) (e) above).

- (e) *Key has been omitted or is sheared between planetary gears.* Remove main support housing. Inspect and install key if necessary.
- (f) *Key sheared at no-back driven bearing.* Turret may rotate erratically in manual drive. Disassemble, replace key and if necessary the no-back bevel gear ((4) (b) above).

d. Power Traversing Trouble.

- (1) *Manual crank arm in power position. Hydraulic motor fails to rotate.*
 - (a) *Micro-switch at handle is not functioning.* Inspect electric circuit, short micro-switch, and replace if necessary (par. 9).
 - (b) *Micro-switch not set properly.* Relocate micro-switch on its mounting bracket to engage crank arm level lock (D, fig. 71).
 - (c) *Lever of manual crank handle does not contact micro-switch.* Lever lock and linkage may be binding. Inspect and repair linkage.
 - (d) *Dump-valve fails to pass piston operating pressure.* With power switches "ON", operate micro-switch from motor to manual drive position. Remove filter cap of reservoir and observe dumping action of valve where it returns fluid to the reservoir. Inspect and repair electrical system (par. 9), hydraulic system, or dump valve (par. 10).
 - (e) *Piston stuck in manual drive position.* Remove power-traversing-bypass valve. Inspect for freedom of piston movement. Repair or replace if necessary (par. 50).
 - (f) *Shift-shaft gear in the differential remains in manual drive position.* Bolt holding shift-shaft gear to differential shifting piston assembly may have become loose. Remove power-traversing-bypass valve. Inspect bolt. Inspect differential gear teeth for mutilation, replace defective parts and install bolt washer and lock washer to shift-shaft gear.
 - (g) *Oil seal leak in differential shifting piston assembly.* Presence of hydraulic fluid at traverse pinion gear indicates leakage past lower oil seal ring. Pressure loss may be great enough to disable piston. Leakage from upper oil seal (VV, fig. 73) indicated by presence of fluid escaping between power-traversing-bypass valve and piston housing, may be great enough to prevent piston from operating.

- (h) *Power-traversing-bypass valve may be stuck in the manual position.* Remove bypass valve, test and replace if necessary (par. 51).
- (i) *Power-traversing-bypass valve may be worn.* Worn valve-spool will cause abnormal leakage across the two main pressure lines to the hydraulic motor. Leakage past valve-spool will prevent power operation (fig. 76). Remove valve ((h) above). Replace.
- (2) *Manual-traversing handle spins when commander's override control is used.* No-back lock fails to "lock" and bolt has become loose from differential shift-shaft gear. Unit assembly is driven by hydraulic motor with differential shift-shaft gear in manual position. Remove, inspect, and repair or replace no-back lock (par. 46). Remove, inspect, and replace differential assembly if necessary (par. 48).
- (3) *Turret traverse speed is slow but hand drive torque is normal.*
 - (a) *"Spool" in the power-traversing-bypass valve is worn.* Hydraulic pressure in the power operation position of the valve, can flow as in the manual position. Remove and replace power-traversing-bypass valve (par. 51).
 - (b) *Power-traversing-bypass-valve spring is bent.* Bent spring prevents "spool" of valve assembly from attaining a full closed position. Remove, inspect, and repair. If necessary, replace assembly (par. 51).
 - (c) *Hydraulic motor has developed slippage or leakage.* Refer to paragraph 10.
- (4) *Unit stalls in power operation after extended traversing at slow speeds.* High speeds of differential single and double planet gears (fig. 73) after extensive use, may cause bearings to freeze. When overheating at housings enclosing the differential accompany stalling of turret traversing, test manual drive torque. Remove hand drive and shifting mechanism. Inspect and repair or replace differential (par. 48).
- (5) *Gear noise is present during power operation.*
 - (a) *Shift-shaft gear in differential is loose from piston and is riding on single planetary differential gears.* Lock turret. Apply hand effort. If manual effort at hand crank results in audible gear stripping noises and handle will rotate, remove hand drive and shifting mechanism. Inspect, repair or replace differential (par. 48).
 - (b) *Spherical bearings in traversing mechanism are worn or defective.* Inspect both main shaft drive gears for wear.

Remove spherical bearing caps and inspect bearings. Replace bearings (par. 35).

(6) *Switching action is sluggish.*

(a) *Piston oil seal rings are leaking.* Inspect traversing drive gears for presence of hydraulic fluid. Inspect for presence of hydraulic fluid between power-traversing-bypass valve and piston housing. Loss of pressure may be sufficient to increase time required to operate piston (pars. 41 and 45).

(b) *Piston is binding in the housing.* Remove power-traversing-bypass valve and inspect piston and housing inside diameters for vertical interference lines. Repair or replace piston assembly (par. 50).

(c) *Power-traversing-bypass-valve spool is sticking in bypass-valve housing.* Remove power-traversing-bypass valve and test valve. Replace complete assembly if necessary (par. 51).

(d) *Supercharge pressure of hydraulic system may be below normal.* Disconnect hydraulic line to piston assembly, and test pressure from gear pump. Refer to paragraph 10.

(7) *Power operation is possible although power requirements become high.*

(a) *Bearing may be damaged in traversing mechanism.* Test torque required to traverse turret manually. Remove hydraulic motor and hand drive. Test traversing torque required by the traverse mechanism's gear train. Isolate high torque assembly. Replace defective bearings.

(b) *Foreign matter in gear system.* Clean and lubricate. Check traverse pinion torque (par. 49).

(c) *Binding of differential planet gears will increase power torque requirements.* Use commander's control to traverse turret at a medium tracking rate. Simultaneously rotate traverse hand crank slowly to measure abnormal torque-pickup developed at cage of differential. See "WARNING" in paragraph 45.

Caution: No-back lock must be operating properly before attempting rotation of manual traverse handle while operating turret from commander's controls.

(8) *Unit fails to shift properly from power to manual operation.* Differential timing may have been disturbed by repair or disassembly operations. High hand drive effort will be apparent. Eventual overheating and freezing of gears on bearings will result. Remove hand drive and shifting mechanism. Inspect and retime differential (par. 48).

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CHAPTER 3

PULSING RELAY SYSTEM

Section I. DESCRIPTION AND PRINCIPLES OF OPERATION

12. Description

(fig. 3)

The pulsing relay system consists of the following components: a commander's control handle, gunner's control handle, override control box, pulsing relay box, two signal motors, and a limit switch assembly. The pulsing relay system sends signals to the hydraulic system which provides the power necessary for accurate and rapid movement of the turret in traverse and the gun in elevation. The system enables the crew commander to take control of the guns at any time.

a. Commander's Control Handle (figs. 4, 5, and 20). The commander's control handle is the component of the pulsing relay control system used by the commander to take control of the system. The unit consists of a cast aluminum, water-resistant housing to which is attached a pistol grip movable about two axes. Mechanical linkages transmit the motion of this handle to two potentiometers mounted within the housing; one for each axis of handle motion. Mechanical centering of the handle to a neutral position is provided. Four micro-switches are used at the potentiometer end of the linkage to determine direction of potentiometer circuit and width of neutral zone, two for each axis. Four micro-switches are also incorporated at the potentiometer end of the linkage, two for each axis; these provide slewing speeds at maximum handle deflection. The pistol grip contains a waterproof switch with a trigger and a waterproof override switch. Two electrical receptacles are mounted on the housing. Rubber bellows are used to seal the linkage coming through the housing wall, thereby making the potentiometer chamber of the housing waterproof.

b. Gunner's Control Handle (figs. 6, 7, and 24). The gunner's control handle is used by the gunner to position the guns on a target. The unit consists of a cast aluminum water-resistant housing to which are attached two pistol grips, the right one being movable about two

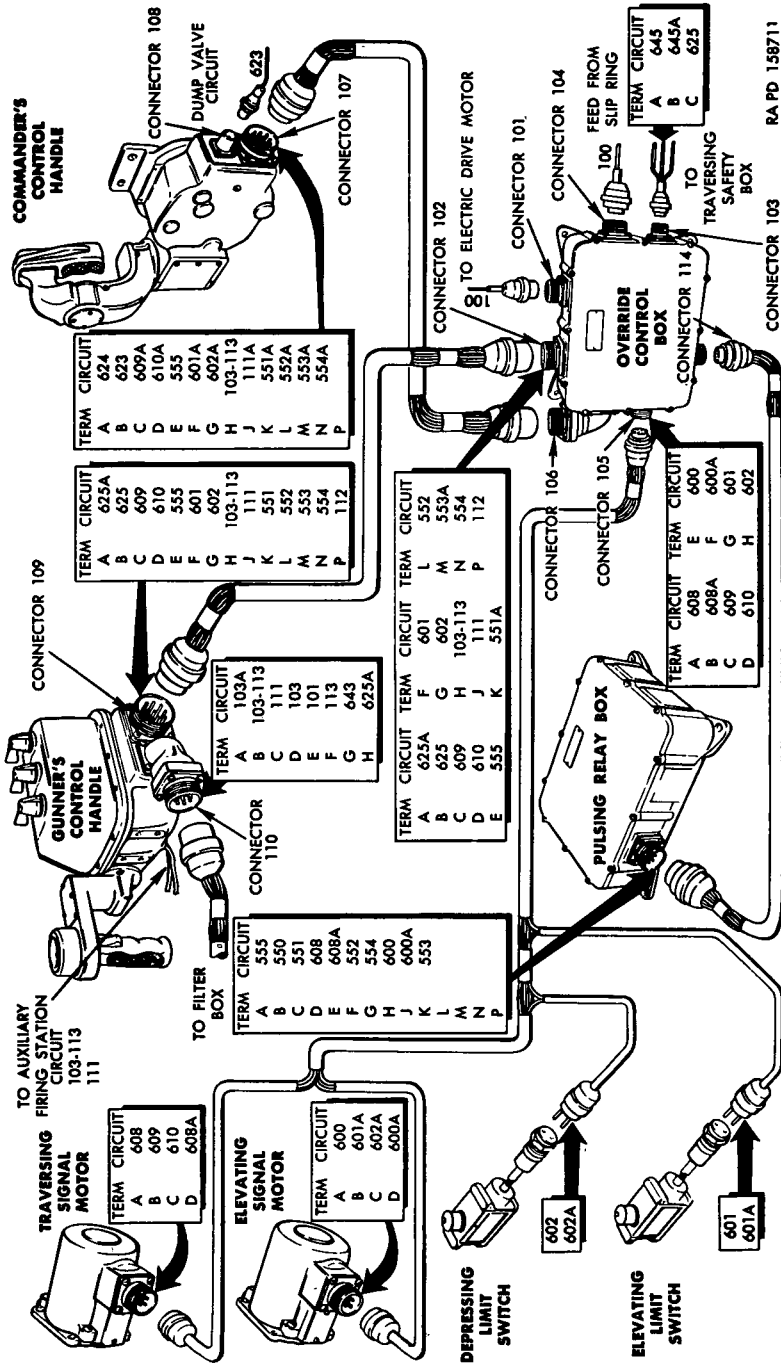


Figure 3. Pulsing relay system components.

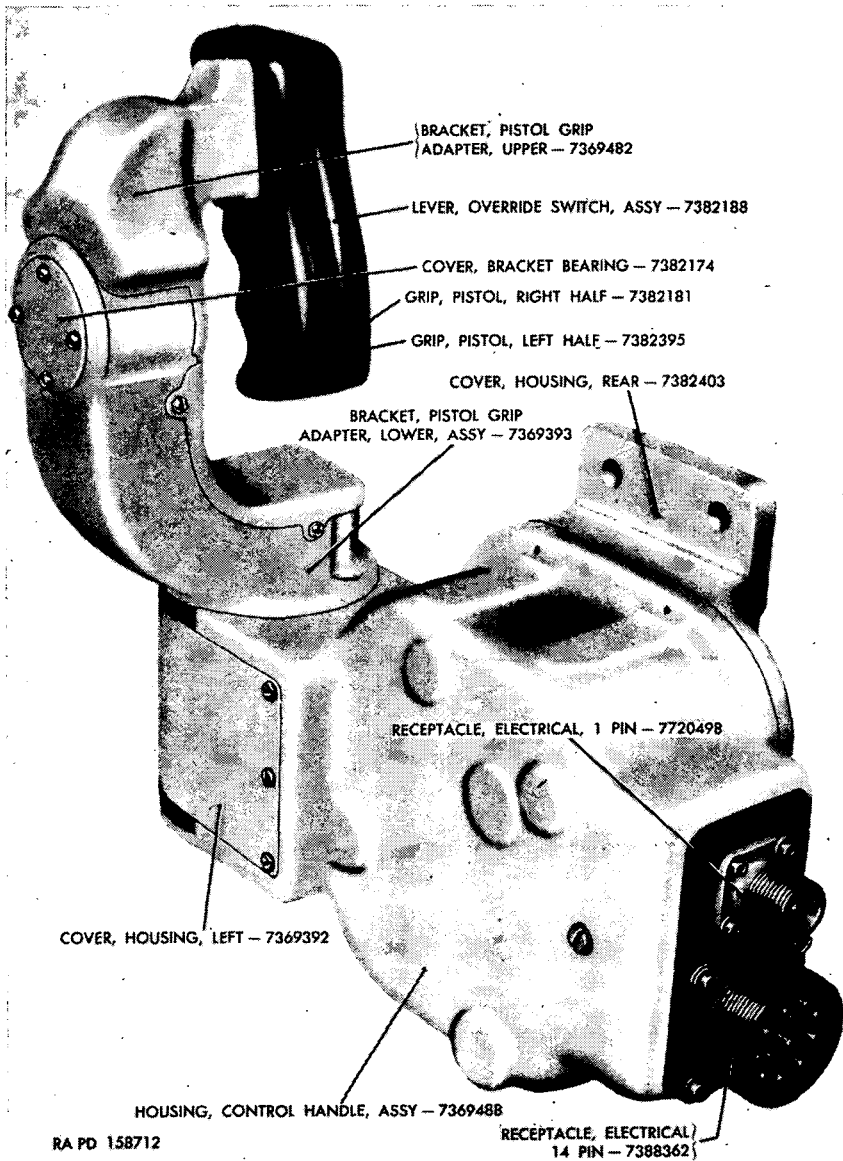


Figure 4. Commander's control handle—left-side view.

axes, the left one is stationary. Mechanical linkages transmit the motion of the right pistol grip to two potentiometers mounted within the housing; one for each axis of handle motion. Mechanical centering of the handle to a neutral position is provided. Four micro-switches are used at the potentiometer end of the linkage to determine

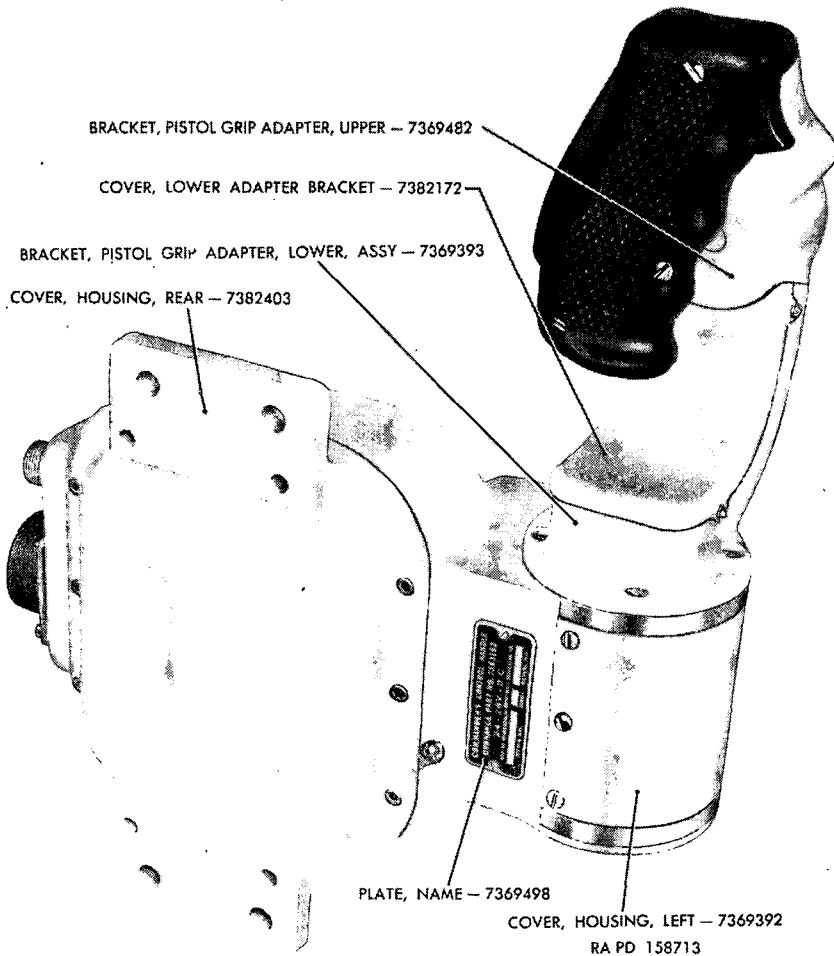
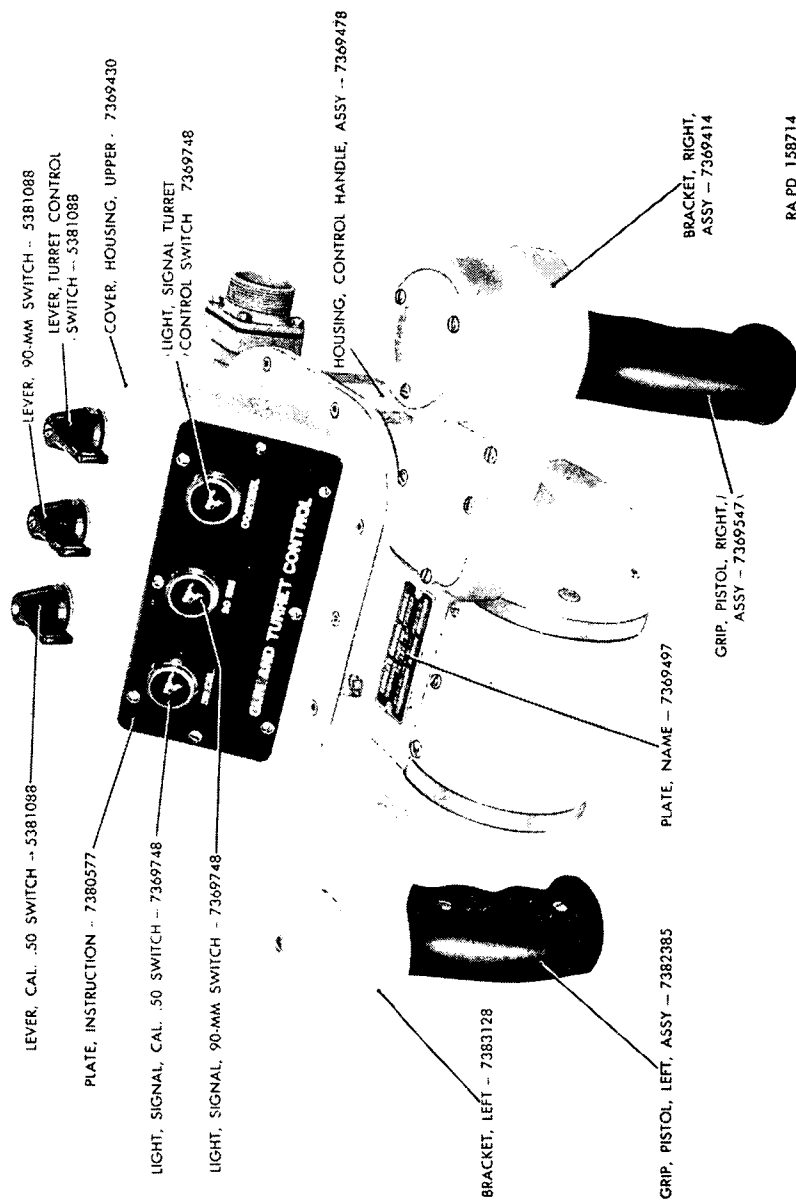


Figure 5. Commander's control handle—right-side view.

direction of potentiometer circuit and width of neutral zone, two for each axis. Four micro-switches are also incorporated at the potentiometer end of the linkage, two for each axis, to provide slewing speeds at maximum handle deflection. The handles contain waterproof switches with triggers for firing the 90-mm and cal. .50 guns. Two electrical receptacles are mounted on the housing. Rubber bellows are used to seal the linkage coming through the housing wall thereby making the potentiometer chamber of the housing waterproof. A turret control switch, a cal. .50 gun selector switch and 90-mm gun selector switch are mounted in the upper housing cover.



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Figure 6. Gunner's control handle—front view.

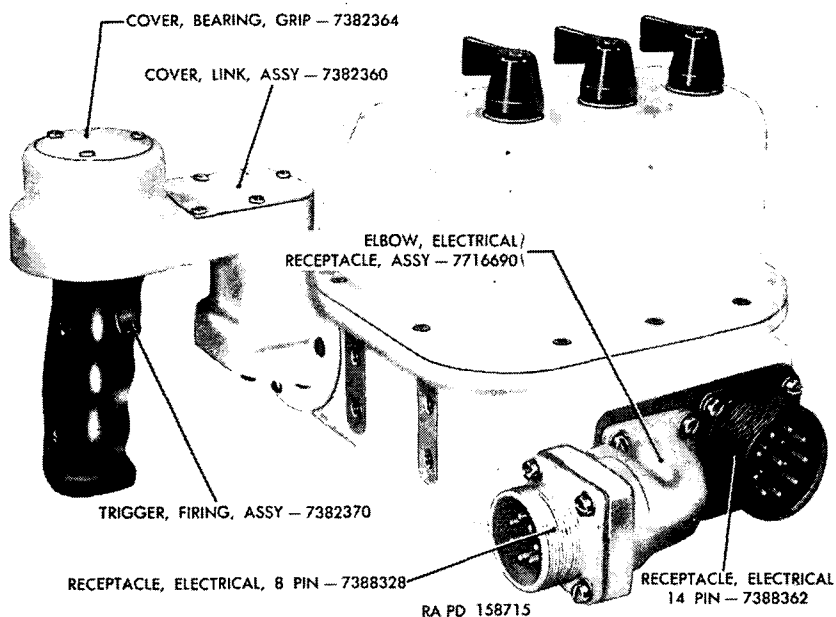


Figure 7. Gunner's control handle—rear view.

c. *Override Control Box* (figs. 8, 29, and 31). This component is actually a junction box used to connect the various electrical controls required for the complete control system used in aiming and firing the guns. It has electrical receptacles (fig. 3) for completing the electrical connections to the electric drive motor, traversing safety box, traversing and elevating signal motors, elevating and depressing limit switches, gunner's control handle, commander's control handle, and the pulsing relay box. The override control box contains 26-volt dc relays that are energized by the commander's override switch, which transfers the control functions (traversing, elevating, and firing) from the gunner's control handle to the commander's control handle. It contains a third remotely controlled relay which starts and stops the electric drive motor. It contains two 15-amp circuit breakers and one 200-amp circuit breaker for overload protection of other external electrical components of the control system. The override control box is waterproof for protection of its internal components. It is mounted by means of integral mounting lugs.

d. *Pulsing Relay Box* (figs. 9, 33 and 34). The pulsing relay box is the speed controlling component in the remote position turret control. It functions in conjunction with the gunner's and commander's control handles to provide two channels of control, one for the elevating axis and one for the traversing axis. It consists of a waterproof en-

[illegible]

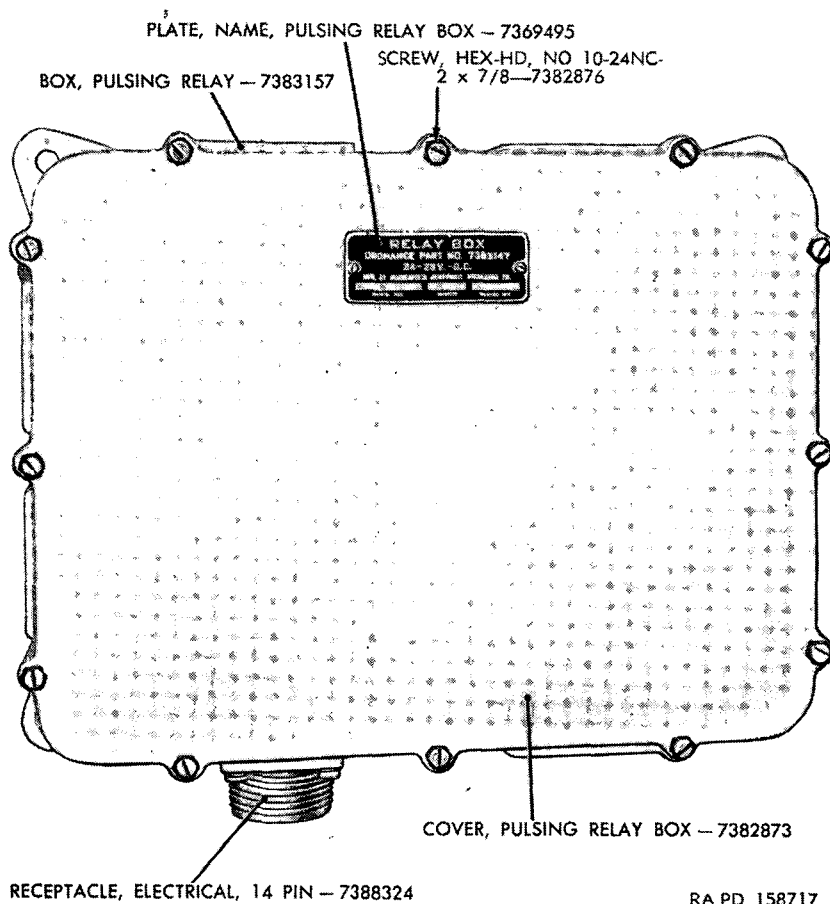
- G**—RECEPTACLE, ELECTRICAL, 14
CONTACT — 7388325
H—RECEPTACLE, ELECTRICAL, 8
CONTACT — 7388329
J—COVER, OVERRIDE CONTROL BOX
— 7382873
K—BOX, OVERRIDE CONTROL
— 7369690
L—ELBOW, ELECTRICAL RECEPTACLE,
— 7716691

Figure 8. Override control box-front view

60

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displacement of the potentiometers in the commander's or gunner's control handle and for direction of rotation information upon the operation of the motor field selecting micro-switches also located in the control handles.

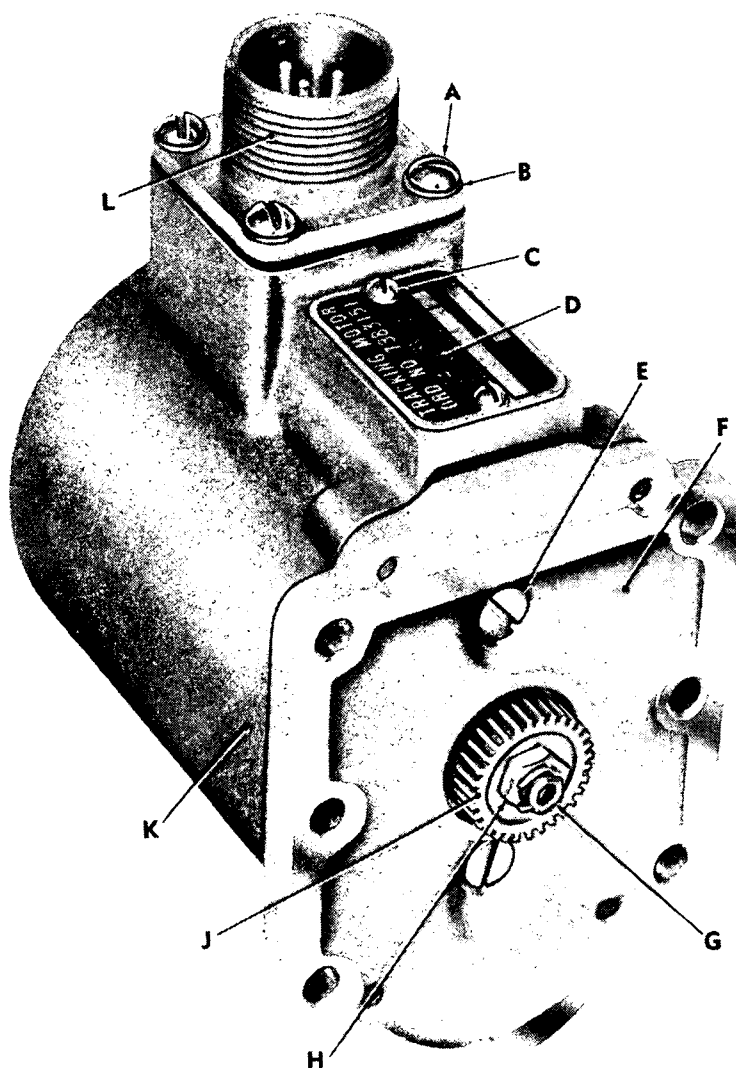


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Figure 9. Pulsing relay box—front view.

e. Signal Motors (figs. 10 and 35). The signal motors are mounted on the hydraulic pump control assembly. The system requires one motor for control of the traversing axis and one for control of the elevating axis. It is a two-pole d-c motor having one field winding on each pole piece. One field winding is energized for rotation in one direction and the other is energized for reverse rotation. Both brush holders are insulated. It is contained in a cast aluminum housing having a flange at one end for mounting. Electrical connections are made through an electrical receptacle on the case.

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A—SCREW, RD-HD, NO 6-32 x
3/8—132696

B—WASHER, LOCK, NO 6
— 138526

C—SCREW, RD-HD, NO 2-56 x
1/8—421550

D—PLATE, NAME — 7369516

E—SCREW, FL-HD, NO 6-32 x 2
— 100813

F—PLATE, END, MOTOR
— 7383164

G—ARMATURE, W/COM-
MUTATOR, ASSY — 7369470

H—NUT, HEX, NO 10-32
— MHR-16930-19

J—GEAR, DRIVE, MOTOR
— 7383166

K—HOUSING, MOTOR — 7383165

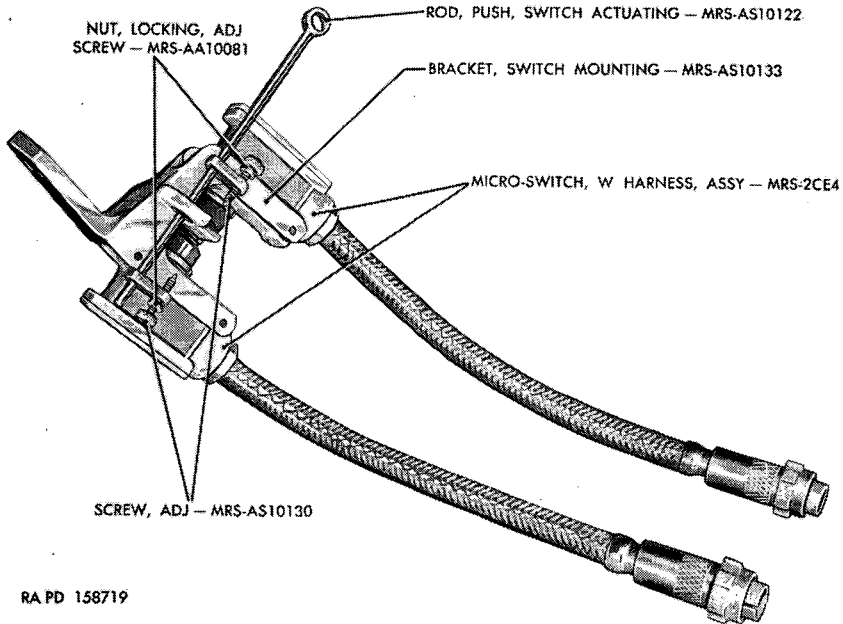
L—RECEPTACLE, ELECTRICAL,
ASSY — 7524938

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Figure 10. Signal motor—drive end.

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f. *Elevating and Depressing Limit Switch Assembly* (fig. 11). The limit switch consists of two micro-switches contained in separate cast aluminum water-resistant housings. The housings are connected to a mounting bracket. There is an electrical harness and receptacle connected to each housing.



RA PD 158719

Figure 11. Elevating and expressing limit switch assembly.

13. Principles of Pulsing Relay Circuit

The pulsing relay system (figs. 3 and 12) was designed and built around a basic circuit (fig. 13). Once the basic circuit is understood it will not be difficult to perform trouble shooting and understand the theory of the pulsing relay system and to follow the pulsing relay system wiring diagram (fig. 12). The following paragraphs begin with the basic circuit and add the function of each component in a step by step procedure. Refer to table I for circuit names and numbers.

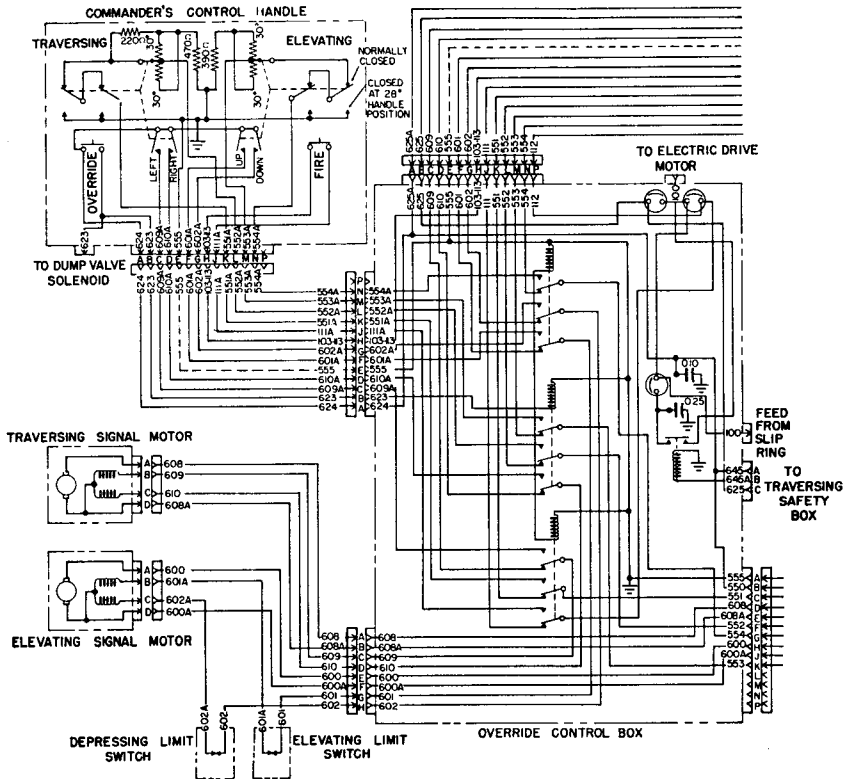


Figure 12. Pulsing relay system—wiring diagram.

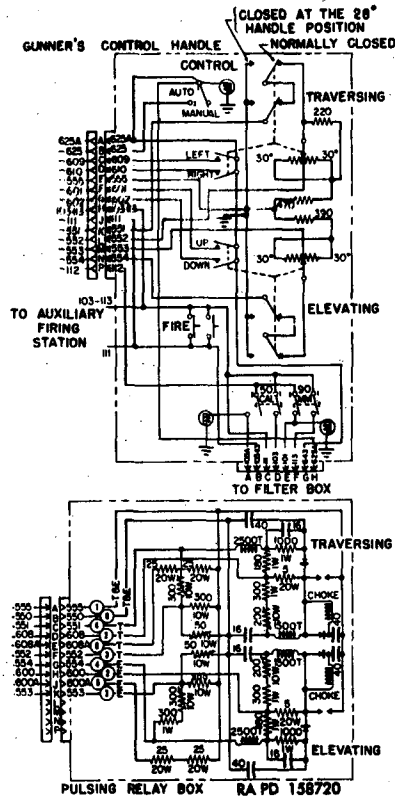


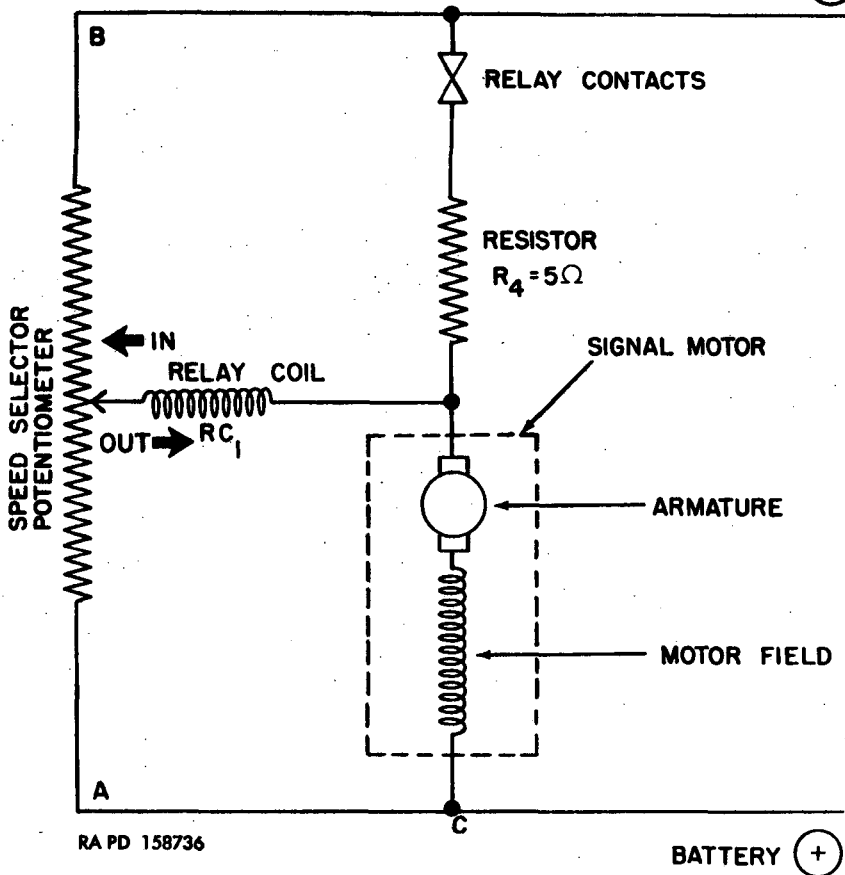
Figure 12. Pulsing relay system—wiring diagram—Continued

Table I. Electrical Circuit Numbers

Circuit No.	Circuit name
100	Power from slip ring and power to electric drive motor.
101	Power to 90-mm firing relays.
103	Cal. .50 firing circuit.
103-113	Firing circuit from commander's control handle to gunner's control handle.
103A	Power to cal. .50 firing relay.
111	Power from override relay to gunner's control firing switch.
111A	Power from override relay to commander's control firing switch.
112	Power for firing circuits to general's control selector switches.
113	90-mm firing circuit.
550	Power to pulsing relay box.
551.	Traversing control circuit from gunner's control handle to traversing pulsing relay through override relay.
551A	Traversing control circuit from commander's control handle to override relay.

Table I. *Electrical Circuit Numbers—Continued*

Circuit No.	Circuit name
552	Power to traversing control potentiometer in gunner's control handle from pulsing relay box through override relay.
552A	Power for traversing control potentiometer in commander's control handle from override relay.
553	Power for elevating control potentiometer in gunner's control handle from pulsing relay box through override relay.
553A	Power for elevating control potentiometer in commander's control handle from override relay.
554	Elevating control circuit from gunner's control handle to elevating pulsing relay through override relay.
554A	Elevating control circuit from commander's control handle to override relay.
555	Ground circuit (vehicle chassis completes part of this circuit in actual use).
600	Armature of elevating signal motor to pulsing relay box.
600A	Junction of armature and fields in elevating signal motor to pulsing relay box.
601	"Up" directional switch in gunner's control handle to elevating limit switch through override relay.
601A	"Up" directional switch in commander's control handle to override relay; also elevating limit switch to field of elevating signal motor.
602	"Down" directional switch in gunner's control handle to depressing limit switch through override relay.
602A	"Down" directional switch in commander's control handle to override relay; also depressing limit switch to field of elevating signal motor.
608	Armature of traversing signal motor to pulsing relay box.
608A	Junction of armature and fields in traversing signal motor to pulsing relay box.
609	"Left" directional switch in gunner's control handle to field of traversing signal motor through override relay.
609A	"Left" directional switch in commander's control handle to override relay.
610	"Right" directional switch in gunner's control handle to field of traversing signal motor through override relay.
610A	"Right" directional switch in commander's control handle to override relay.
624	Power to override switch in commander's control handle.
625	Power to traversing safety box for pilot lamp and to turret control switch in gunner's control handle.
625A	Power to control system from turret control switch in gunner's control handle.
643	Power from turret control switch in gunner's control handle to range finder inverter.
645	Power to traversing safety box for relay circuit.
645A	Power to electric drive motor control relay from traversing safety box.



BATTERY (+)

RECONSTRUCTION

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voltage source. A current in this direction through the relay coil (RC_1) will tend to open the relay contacts of the relay, since it is polarized, and the signal motor will cease running. With the contacts again open, current will flow in a direction to close the relay and the cycle will be repeated. Moving the contactor closer to (B) will decrease the impedance of the closing or "IN" current path, and increase the impedance of the "OUT" current path. Thus, the relay contacts will remain closed longer, because of the greater time required to build up enough current in the "OUT" direction to overcome the current tending to hold the relay contacts closed. With the relay contacts closed for a longer percentage of the time, the average current through the motor will increase and the motor will run faster. A certain amount of speed regulation is inherent in the system in that the back emf of the motor will decrease the "IN" current as the motor approaches the speed called for. With the contactor set at a certain position, the current tending to close the relay contacts will have a certain value before the motor begins to rotate. As the motor starts to rotate and build up speed, its effective impedance will increase due to the back emf, reducing the current in the "IN" direction. Thus, as the motor picks up speed, the current tending to open the relay contacts does not have to build up to as high a value as it would were the motor not turning, in order to open the relay contacts. Therefore, if a load were applied to the motor it would not turn as fast, less back emf would be generated, the relay contacts would tend to be closed longer increasing the average motor current, and the motor would have an increased torque. Thus, as the contactor position is changed from (A) toward (B) the relative closed time of the relay contacts is increased. This increases the length of current pulses to the motor, increasing the average current to the motor, and increases the motor speed. The basic circuit has many shortcomings. These will be explained as the components used to compensate for the shortcomings are added to the system.

b. Achieving Two-Directional Control (fig. 14). Current flow through the motor field (F_1) will result in clockwise motor rotation, while current flow through the motor field (F_2) will give counter-clockwise rotation. By placing a micro-switch in series with each field, either field can be energized by actuating one micro-switch or the other. These micro-switches are actuated by a cam on the same shaft as the potentiometer contactor. Thus, if the pistol grip (figs. 5 and 6) is displaced several degrees to the right, the micro-switch energizing motor field (F_1) is actuated. If the pistol grip is moved to the left, motor field (F_2) is actuated. In order to make the potentiometer identical in both directions, point (A) of figure 13 is made

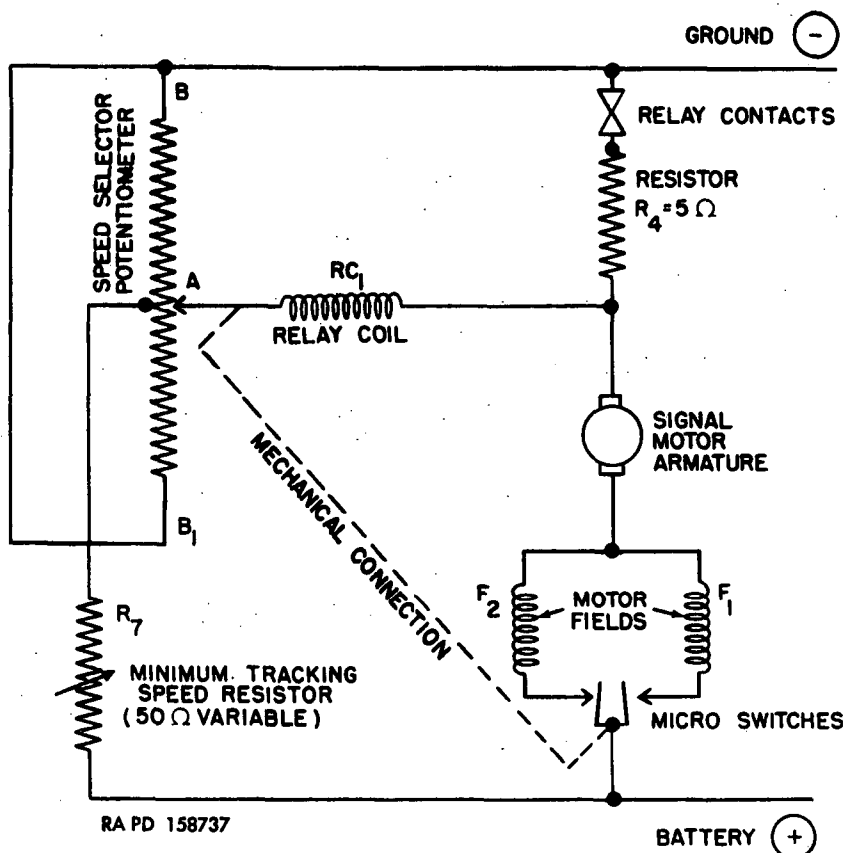


Figure 14. Two-directional-control circuit—schematic diagram.

point (A) of figure 14, a center tap on the potentiometer, and the two ends of the potentiometer are electrically connected. Thus, electrically, the potentiometer is identical between (A) and (B) and (A) and (B₁) and the pistol grip displacement in either direction from neutral or center position will produce identical motor response (speed), but in the opposite directions. The minimum tracking speed resistor (R₇) is added to eliminate the electrical neutral zone in the potentiometer. With point (A) connected directly to the positive (+) side of the line, the contactor would have to be moved a certain distance from (A) before enough current would flow through the relay coil (RC₁) to actuate the relay contacts. By adding variable resistor (R₇) between point (A) and the positive (+) side of the line, point (A) can be placed at a potential below the positive (+) line. The resistor (R₇) is set to such a value that when the field micro-switches are actuated, the slowest motor speed is immediately

attained. Without the minimum tracking speed resistor (R_7) the micro-switch may be adjusted to be actuated at approximately 3° but the contactor may have to be moved 6° before enough current flows through the relay coil (RC_1) to actuate the relay contacts. By setting the minimum tracking speed resistor (R_7) at the right value, enough current flows through the relay coil (RC_1) when the contactor is at 3° to provide the minimum tracking speed at that point. Thus, the electrical neutral zone is reduced from 6° to 3° .

c. *Obtaining Good Contact Action* (fig. 15). To provide good contact action, a second relay coil (RC_2) is added to the pulsing relay. A capacitor (C_R) is also necessary. This portion of the circuit, has no effect on the system until the relay contacts close. The instant that the contacts close, a transient path is provided from the power source through capacitor (C_3), relay coil (RC_2), the relay contacts, and to ground. Current flow in this direction through relay coil (RC_2) will be in a direction to close the relay contacts. The high transient surge through capacitor (C_3) and relay coil (RC_2) as the contacts initially close will cause the relay to snap shut rapidly and make good contact. Relay coil (RC_2) will aid in the opening of the relay contacts. Thus, relay coil (RC_2) and capacitor (C_3) provide definite, positive contact

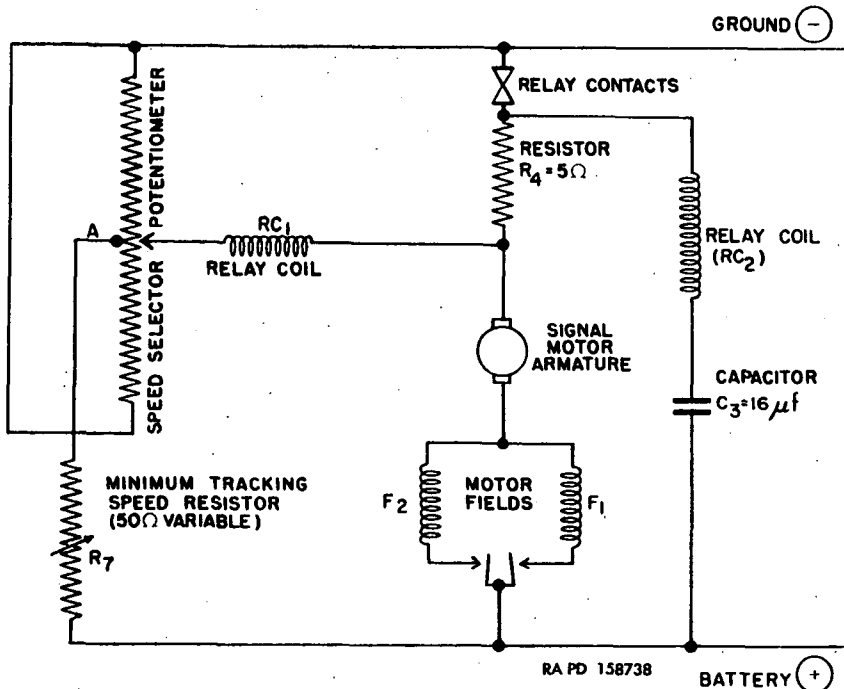


Figure 15. Circuit for providing good contact action—schematic diagram.

action. At the same time that capacitor (C_3) and relay coil (RC_2) provide good contact action, they also tend to increase the length of time that the relay contacts are closed.

d. *Making Short Relay Closed Time* (fig. 16). To produce the very low signal motor speeds the closed time of the relay must be very short. To attain this goal, capacitor (C_1) and resistor (R_2) are added to the circuit. Capacitor (C_1) provides a transient path from point (A), through relay coil (RC_1), capacitor (C_1), relay contacts, and to ground. When the contacts initially close, a high transient current flows through this path and thus through relay coil (RC_1). The current flow through relay coil (RC_1) is in a direction to open the relay contacts. Thus, the instant the contacts close, capacitor (C_1) has the effect of causing them to open immediately and overcome the tendency of capacitor (C_3) and relay coil (RC_2) to hold them closed for a longer time. Both the circuits involving capacitors (C_1 and C_3) are resistance-capacitance-inductance (RLC) circuits. The time constant of such a circuit is proportional to the resistance in the circuit. Since there is no resistance in the circuit involving capacitor (C_3) other than the resistance of relay coil (RC_2), its time constant is lower

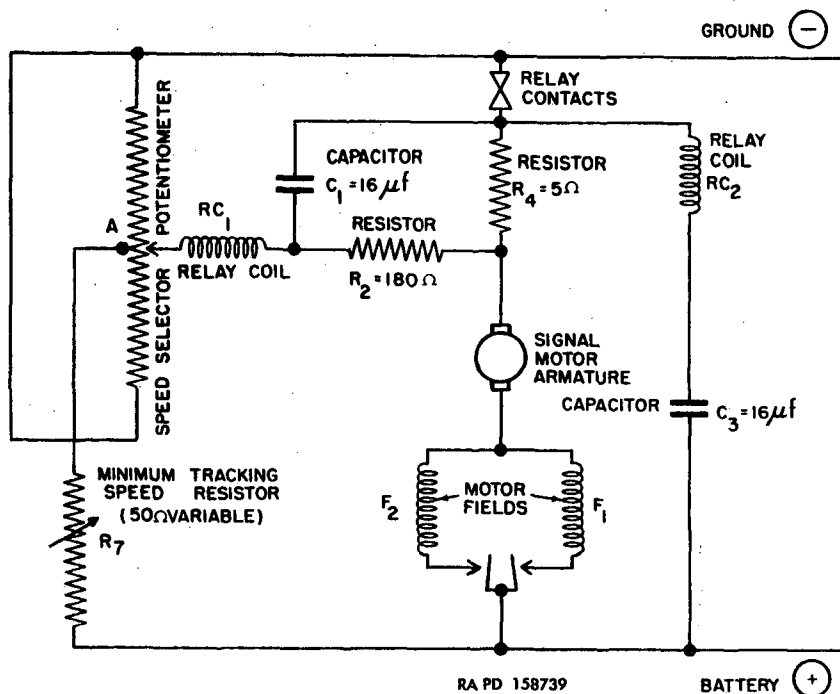


Figure 16. Circuit providing short relay closed time—schematic diagram.

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than the circuit of capacitor (C_1), which has the minimum tracking speed resistance (R_7) and some resistance of the potentiometer added.

Thus, the action of capacitor (C_2) is faster than capacitor (C_1) and will always provide positive relay contact action. The action due to the Capacitor (C_1) will come at some instant after the relay contacts have closed and overcomes the tendency to stay closed for too long a time. As the contactor is moved up the potentiometer (i. e., greater closed time being called for) the resistance in the RLC circuit of capacitor (C_1) is increased, the time constant is likewise increased, and the effect of capacitor (C_1) becomes less and less. Its effect is the greatest at small control handle displacements where such an action is desired. Resistor (R_2) acts as a current block to prevent too great a portion of the transient current to capacitor (C_1) from passing through the motor instead of relay coil (RC_1).

e. Making Long Relay Open Time (fig. 17). At the same time that a very short closed time of the pulsing relay is attained, it is desirable to have a long open time. If the open time is short, then the closed pulses have to be *very* small to reduce the average current through the signal motor—and consequently the motor speed. To obtain the long open time, capacitor (C_2), resistor (R_1), and a selenium rectifier (SR) are added to the circuit. When the contacts close, capacitor (C_2) charges from power source through capacitor (C_2), through selenium rectifier (SR), through the relay contacts, and to ground. Now when the contacts open, selenium rectifier (SR) prevents discharge of capacitor (C_2) through the motor and it must discharge through the minimum tracking speed resistor (R_7), through a portion of the potentiometer (depending on the contactor position), through relay coil (RC_1), through resistor (R_1), and back to capacitor (C_2). The current flow through relay coil (RC_1) is in a direction to hold the relay contacts open, and due to the high resistances in the discharge path, it has a high time constant. Thus, at low control handle displacements, the current in the closed direction is small and the discharge current of capacitor (C_2) tends to hold the relay contacts open for a relatively long time. As the handle is displaced more the current becomes greater and tends to overcome the effect of capacitor (C_2).

f. Controlling Speed Regulation (fig. 18). As previously mentioned in the explanation of the basic circuit, the system has some inherent speed regulation. In order to augment the speed regulation, and to have some control over it, resistor (R_3) is added to the circuit. Here further use is made of relay coil (RC_2). By the use of resistor (R_3) a shunt path across resistor (R_4) is provided. The current in this shunt path flows through resistor (R_3) and through relay coil (RC_2), the amount being regulated by resistor (R_3). This current flow is in the direction to make the relay contacts stay closed longer.

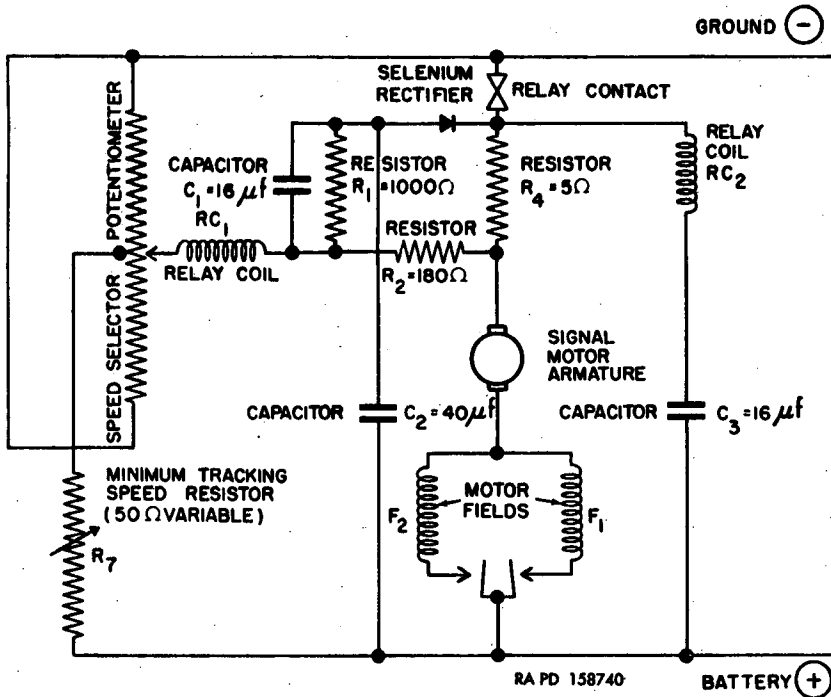


Figure 17. Circuit providing long relay open time—schematic diagram.

It can readily be seen that as the current through resistor (R_4) increases, so will the current through relay coil (RC_2). Thus, if the motor slows down as the load increases at a given handle displacement, its back emf will decrease and the current through resistor (R_4) and relay coil (RC_2) will increase. This will increase the closed time of the relay contacts, providing a greater average current to the signal motor and, consequently, increasing the motor torque to overcome the loading. The lower the value of resistor (R_3) is, the greater is the effect of this speed regulation. However, if this "throttling control" as we call it, is reduced to too low a value, a hunting condition develops. As soon as the contacts close the current through relay coil (RC_2) is great enough to hold the relay contacts closed until the motor speed increases to a point where the back emf limits this current and the relay contacts open. The motor then runs freely until the relay contacts close again and the cycle is repeated. This fault can be detected by a galloping action in the signal motor. The throttling control is set at a value such that when the signal motor is stalled from a free speed of 700 to 1,300 rpm, the relay contacts will close and remain closed.

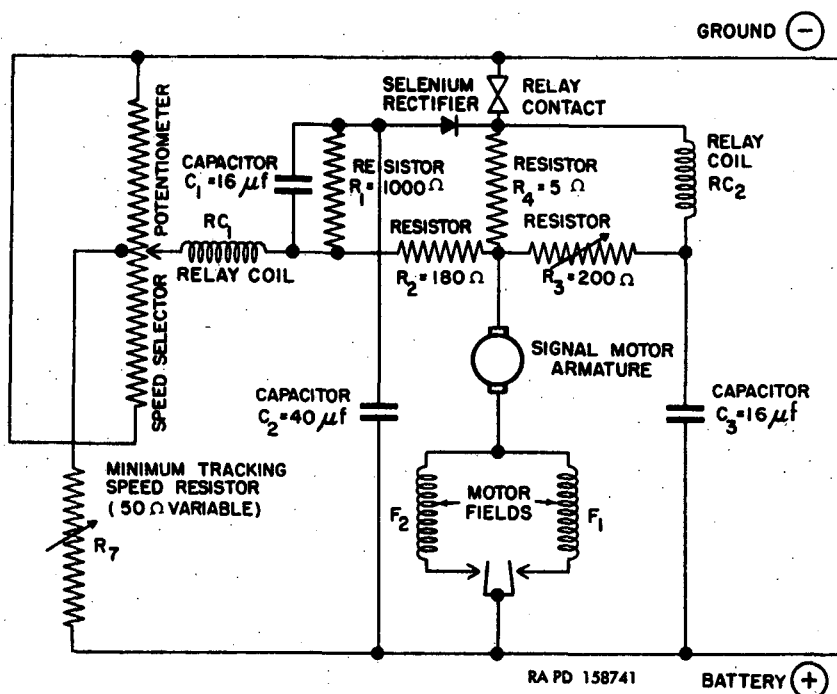


Figure 18. Circuit for controlling speed regulation—schematic diagram.

g. Final Pulsing Relay System (fig. 19). The final circuit is shown in figure 19. Additions to the circuits shown are refinements to provide longer contact life, improved signal motor action, and the desired control handle response curve. Two such circuits are built into each pulsing relay system, one for the elevating axis and one for the traversing axis. The elevating and traversing circuits are identical except for the values of resistors (R_6 and R_{10}). The different resistor values provide different control handle response curves for the two axes. The resistor (R_5) is added to the circuit simply to provide current to the signal motor fields when actuated with approximately one-half-ampere shunt current. This improves the characteristics of the motor considerably and provides increased speed-torque regulation. The arc suppression network prevents material transfer and pitting of the relay contacts. Some small amount of arcing is desirable to aid in cleaning the contacts. The additions to the potentiometer portion of the circuit result in desired handle response curves. The lower one-sixth of the total speed range is used for tracking. That is, a smooth curve is obtained from 0° control handle displacement out to maximum control handle displacement where the top tracking speed is approximately 175 mils per sec. Just beyond that

point the slewing switches are actuated and the turret travels at a slew speed (450 + mils/sec.) for repositioning of the gun. Resistor (R_9) acts as a voltage divider in conjunction with the potentiometer. Thus, when the slewing switch is actuated, the relay coil is switched from the end of the potentiometer directly to the negative line and the relay contacts close and remain closed, resulting in maximum speed of the signal motor. Resistor (R_9) is shunted across the potentiometer and resistor (R_6) raises the effective voltage at the center tap of the potentiometer, making it possible to use a lower value of resistance in the minimum tracking speed resistor (R_7) thus giving greater control handle sensitivity at small displacement. Resistor (R_{13}) is used on the traversing axis only and provides a "droop" to the curve. It is effectively shunted from the contactor to one end of the potentiometer and has its greatest effect at small control handle displacements. As the contactor is moved out from the center tap it is shunted across less resistance and it is much less effective. Resistor (R_{10}) is called the maximum speed control and controls the top tracking speed of the system. It is shunted from the contactor to the center tap of the potentiometer and by changing the value of this shunt resistor the top tracking speed can be varied within limits. Since at low control handle positions the resistance of resistor (R_{10}) is high compared with the resistance between the center tap of the potentiometer and the contactor, it has little effect on the low end of the response curve (approx. 10°). As the resistance of resistor (R_{10}) is increased the slope of the response curve from about 10° to 28° is increased. At the same time the top tracking speed is raised. If resistor (R_{10}) is decreased the slope of the curve becomes less, the top tracking speed is cut down, and the sensitivity of the control handles is reduced.

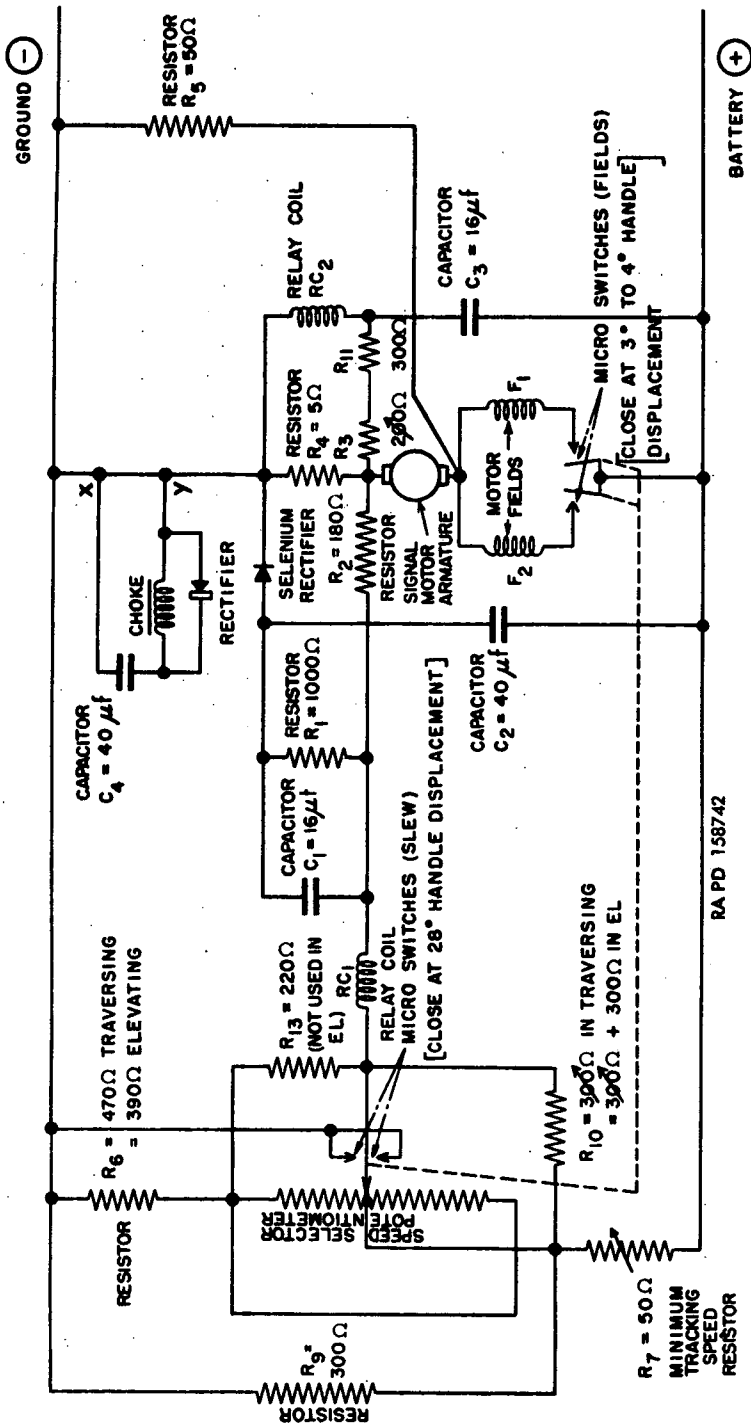


Figure 19. Final pulsing relay system circuit—schematic diagram.

Section II. COMMANDER'S CONTROL HANDLE

14. Description

(figs. 20, 21, 22, and 23)

The commander's control handle consists of a cast aluminum water-resistant housing containing mechanical linkage that transmits the motion of the pistol grip to the electrical components mounted in a waterproof section of the housing. Mounting lugs are cast integrally with the rear housing cover. The pistol grip contains a trigger switch and an override switch encased in waterproof rubber covers. There are two electrical receptacles mounted on the right side of the housing.

15. Principles of Operation

(figs. 20, 21, 22, and 23)

a. General. The function of the commander's handle is to change angular displacement of the pistol grip in a vertical axis into potentiometer contactor movement for the turret traversing circuit and to change angular displacement of the pistol grip in a horizontal axis into potentiometer contactor movement for the gun elevating circuit and to give the commander override at all times, when the gunner is operating in either power or manual control.

b. Data.

Handle movement about axis, from neutral, maximum

Traversing-----	30°
Elevating-----	30°

Neutral zone about axis, from neutral

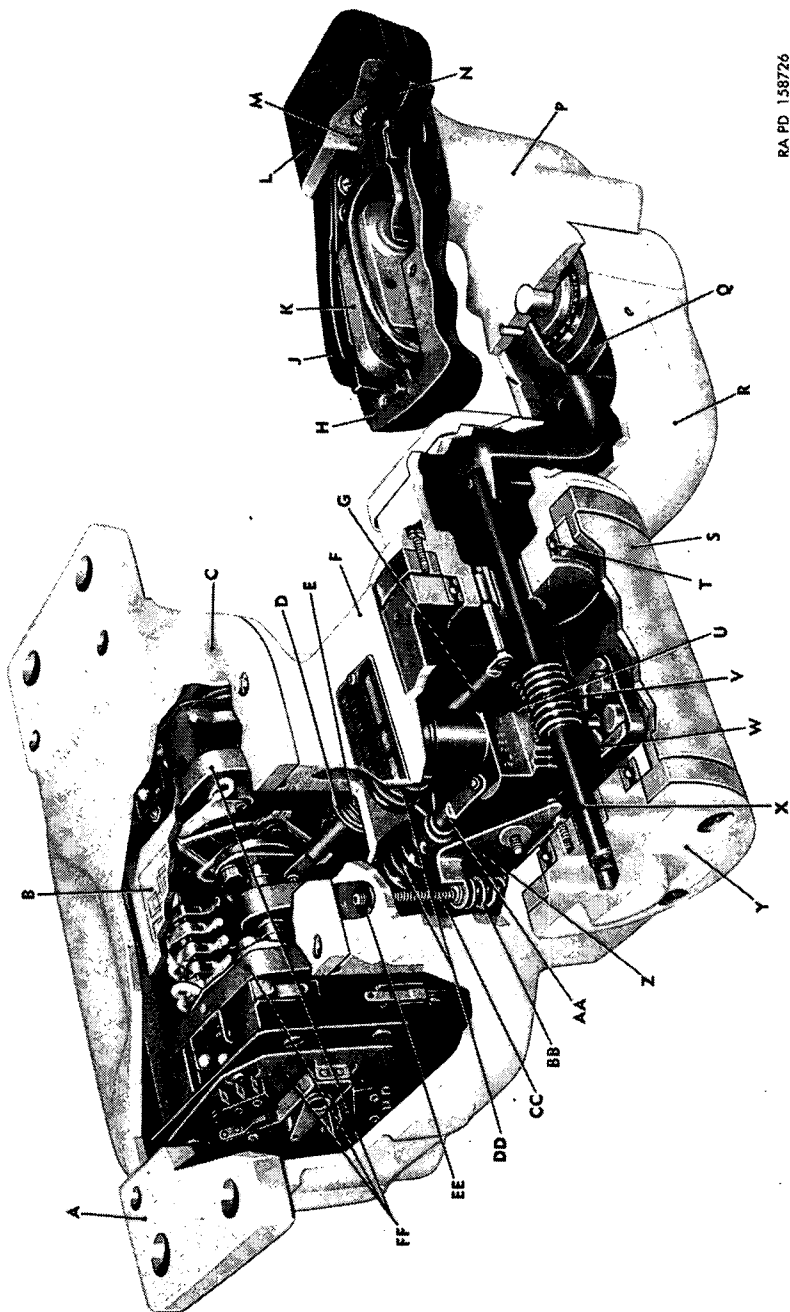
Traversing-----	3°
Elevating-----	3°

Angle at maximum tracking speed, from neutral

Traversing-----	27.5°
Elevating-----	27.5°

Operating voltage, dc----- 24-28 volts

c. Override. In order that the crew commander can assume complete control when necessary an override switch is mounted on the commander's pistol grip which, when actuated, renders the gunner's and the manual control inoperative. When the crew commander depresses the override lever, the override relays in the override relay box are energized so as to disconnect the gunner's control handle and the manual control from the pulsing relay circuit and to connect the commander's control to it instead.



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Figure 20. Commander's control handle—cutaway.

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Figure 20—Continued

A—COVER, HOUSING, REAR—7382403
B—SHIELD, REAR COVER—7369379
C—SCREW, REAR HOUSING COVER—583885
D—SPRING, BELLOWS—7369404
E—SLEEVE, PUSH-ROD—7369434
F—HOUSING, CONTROL HANDLE, ASSY—7369488
G—ROD, PUSH, POTENTIOMETER CONTROL, LONG—
7369341
H—GRIP, PISTOL, LEFT HALF, ASSY—7382395
J—LEVER, OVERRIDE SWITCH, ASSY—7382188
K—SWITCH, OVERRIDE—7401684
L—GRIP, PISTOL, RIGHT HALF—7382181
M—SPRING, COMPRESSION, FIRING TRIGGER—
7382187
N—TRIGGER, FIRING, ASSY—7382183
P—BRACKET, PISTOL GRIP ADAPTER, UPPER—
7369482
Q—BEARING, BALL BRACKET—712072
R—BRACKET, PISTOL GRIP ADAPTER, LOWER,
ASSY—7369393
S—COVER, HOUSING, LEFT—7369392
T—BEARING, BALL, RACK—710132
U—GEAR, SEGMENT, ASSY—7369376
V—ARM, CENTERING, LONG, UPPER, ASSY—7369338
W—ARM, CENTERING, LONG, LOWER, ASSY—7369373
X—RACK, CIRCULAR—7369332
Y—COVER, HOUSING, BOTTOM, ASSY—7369391
Z—ARM, CENTERING, SHORT, ASSY—7369374
AA—ROD, PUSH, POTENTIOMETER CONTROL,
SHORT—7369352
BB—SPRING, COMPRESSION, CENTERING ARM—
7369478
CC—SCREW, ADJUSTING, CENTERING ARM—7369359
DD—BELLOWS, PUSH-ROD—7369403
EE—NUT, LOCK, SLOTTED, NO. 8-32 NC-2—7369433
FF—BRACKET, POTENTIOMETER, ASSY—7369536

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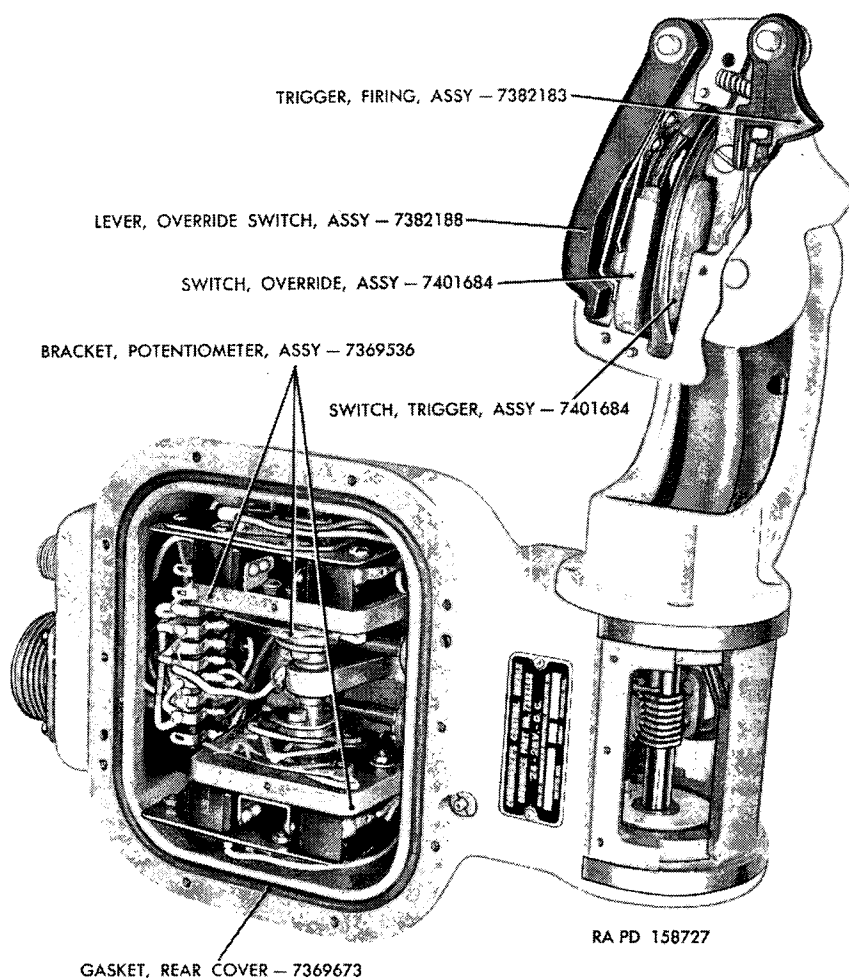


Figure 21. Commander's control handle—(covers removed)—right-side view.

d. Elevating (figs. 20, 21, 22, and 23). Movement of the pistol grip assembly about a horizontal axis regulates the speed and the direction of movement of the signal motor for the gun-elevating pump control mechanism. By-rotating the pistol grip assembly and the adaptor bracket, the link which is attached to the upper adaptor bracket by a pin is given motion. The link converts this rotary motion and transmits it as linear motion to the circular rack which is supported by bearings on each end. Teeth in the circular rack mesh with a segment gear assembly and transmit the motion converting it to rotary motion.

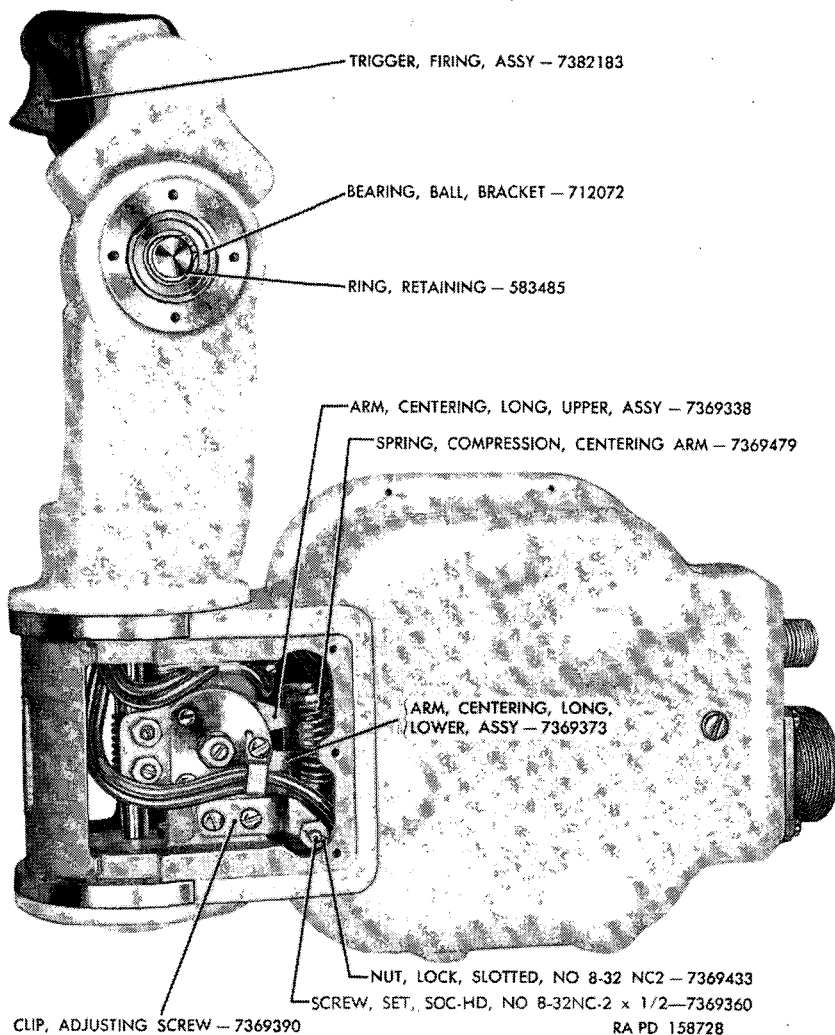


Figure 22. Commander's control handle—(covers removed)—left-side view.

This rotary motion is again converted as linear motion to the short potentiometer control push rod by means of a pin. The push rod is connected to the arm assembly on the shaft assembly of the potentiometer bracket assembly, giving the shaft assembly rotary motion. Rotary motion of the shaft assembly results in several actions being accomplished. The potentiometer contactor slides along the potentiometer and the collector ring thus varying the circuit resistance, one of the two directional micro-switches is actuated, depending upon



Figure 23. Commander's control handle—schematic wiring diagram.

whether shaft rotation is clockwise or counterclockwise, and as the shaft reaches its rotational limit (30° clockwise or 30° counterclockwise), one of the two slewing switches, depending upon the direction of the shaft rotation, is actuated to cause the gun-elevating mechanism to run at full speed. The adaptor bracket and the shaft assembly are returned to a center-neutral position on release of the pistol grip by means of the centering arm spring (fig. 22). The centering arm spring pushes against two centering arm assemblies which in turn tend to force a pin which is attached to the gear assembly to its neutral position. Travel limits of 30° in each direction are defined by milled stops in the upper adapter bracket which contact a stop pin fastened to the lower adapter bracket assembly.

e. Power Traversing (fig. 20, 21, 22, and 23). Movement of the pistol grip assembly about a vertical axis regulates the speed and direction of movement of the signal motor for the turret traversing pump control mechanism. The lower adapter bracket assembly is fastened securely to the connector and bottom housing cover assembly. This entire assembly rides on two rack ball bearings supported by the control handle housing assembly. By rotating the lower adapter bracket assembly about a vertical axis, a pin pressed into the bracket is

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given motion and transmits it to the long potentiometer control push rod. The push rod is attached to the shaft assembly of the potentiometer bracket assembly and the motion is similar to the motion for elevating. Stops milled in the housing define the travel limits of 30° in each direction of the connector and thus limit potentiometer contactor travel. Directional micro-switches and slewing micro-switches are provided for traversing the turret which function in a manner similar to those for elevating the gun.

f. Firing (fig. 20, 21, 22, and 23). A firing trigger and a trigger switch assembly are mounted in the pistol grip. When the trigger is depressed it pivots about a pin pressed into the pistol grip and forces a lever to trip the trigger switch. The trigger switch closes the firing circuit to the gun. A firing trigger compression spring forces the lever and firing trigger away from the trigger switch when the trigger is released.

Section III. GUNNER'S CONTROL HANDLE

16. Description

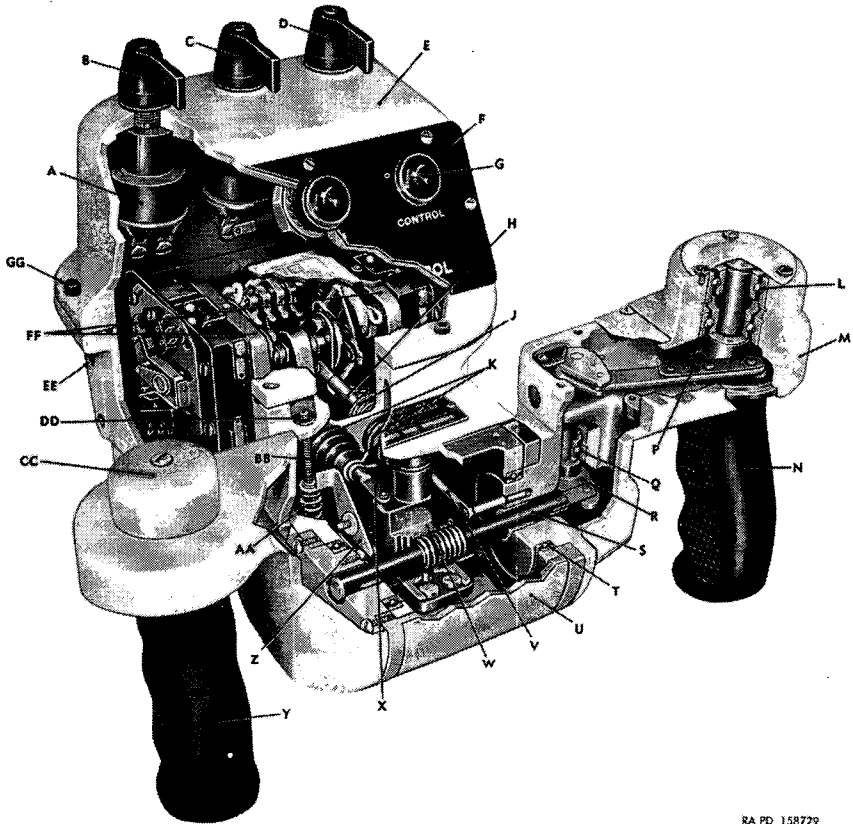
(figs. 24, 25, 26, 27, and 28).

The gunner's control handle consists of a cast aluminum water-resistant housing containing two pistol grips and mechanical linkage that transmits motion from the handles to the electrical components mounted within a waterproof section of the housing. Mounted on top of the upper housing cover are the cal. .50 gun switch, 90-mm gun switch, and the turret control switch with signal lights to show when circuits are closed. There are two electrical receptacles mounted on the rear of the housing.

17. Principles of Operation

(figs. 25, 26, 27, and 28)

a. General. The functions of the gunner's control handle are to change rotary displacement of the right pistol grip about the horizontal axis into potentiometer contractor movement for the gun elevating circuit, change rotary displacement of the pistol grip about the vertical axis into potentiometer contractor movement for the turret traversing circuit, to select the firing circuit desired, and to control the selection of manual or power traversing and elevating.



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Figure 24. Gunner's control handle—cutaway.

- A—SWITCH, CAL. .50, ASSY—7072832
- B—LEVER, CAL. .50 SWITCH—5381088
- C—LEVER, 90-MM SWITCH—5381088
- D—LEVER, TURRET CONTROL SWITCH—5381088
- E—COVER, HOUSING, UPPER—7369430
- F—PLATE, INSTRUCTION—7380577
- G—LIGHT, SIGNAL, CONTROL, ASSY—7369748
- H—SLEEVE, PUSH-ROD 7369434
- J—SPRING, BELLOWS—7369404
- K—BELLOWS, PUSH ROD—7369403
- L—BEARING, BALL PISTOL GRIP—7382321
- M—BRACKET, RIGHT, ASSY—7369414
- N—GRIP, PISTOL, RIGHT, ASSY—7369547
- P—LINK, ASSY—7382360
- Q—BEARING, BALL, BELL CRANK—7382194
- R—CRANK, BELL, ASSY—7382367
- S—RACK, CIRCULAR—7369332
- T—BEARING, BALL, RACK—710132

Figure 24—Continued.

U—COVER, HOUSING, FRONT—7369392
V—ROD, PUSH, PONTENTIOMETER CONTROL, LONG—7369341
W—GEAR, SEGMENT, ASSY—7369376
X—ROD, PUSH, POTENTIOMETER CONTROL, SHORT—7369352
Y—GRIP, PISTOL, LEFT, ASSY—7382385
Z—ARM, CENTERING, SHORT, ASSY—7369374
AA—SPRING, COMPRESSION, SHORT CENTERING ARM—7369478
BB—SCREW, ADJUSTING, CENTERING ARM—7369359
CC—CAP—7382381
DD—NUT, LOCK, SLOTTED, 8-32NC-2—7369433
EE—HOUSING, CONTROL HANDLE, ASSY—7369478
FF—BRACKET, POTENTIOMETER, ASSY—7369548
GG—SCREW, UPPER HOUSING COVER—583885

b. Data.

Handle movement about axis (from neutral, maximum) :

Traversing -----	30°
Elevating -----	30°

Neutral zone about axis (from neutral) :

Traversing -----	3°
Elevating -----	3°

Angle at maximum tracking speed (from neutral) :

Traversing -----	27.5°
Elevating -----	27.5°

Operating voltage, dc ----- 24-28 volts

Signal light current ----- 0.17 ampere

c. Circuit Selection (figs. 24, 25, and 28). Power is brought into the gunner's control handle from the override control box through a harness at connector (109) (fig. 3). It is led through cables to the three selector switches on the upper housing cover and various other components. When the lever marked "CONTROL" is rotated counterclockwise to its switch stop the control energizing switch is closed, allowing current to actuate a relay which energizes the electric drive motor and to connect the rest of the control system to the power source.

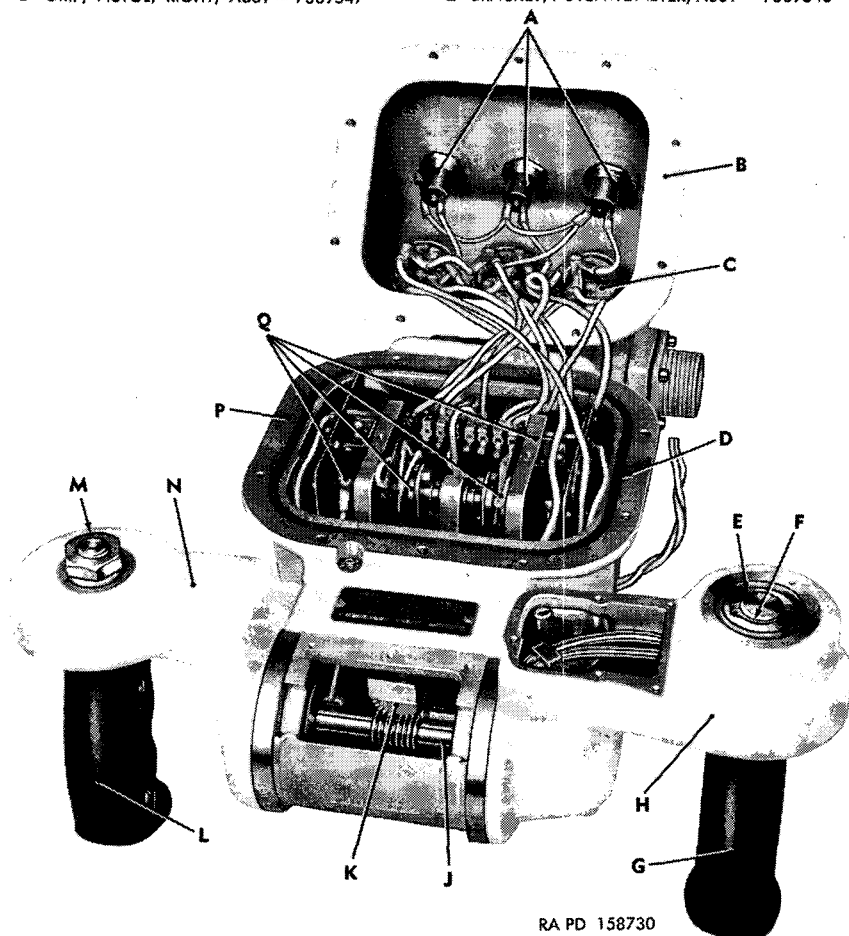
Note. It is necessary that the traversing safety and the master relay switches both be in the "ON" position.

When the lever marked "90-MM" is rotated counterclockwise to its switch stop the firing circuit for the 90-mm gun is energized. When the lever marked "50 CAL" is rotated counterclockwise to its switch stop the firing circuit for the cal. .50 machine guns is energized. A switch signal light is provided for each switch to indicate when that switch is turned on. The firing circuits are operative whether the control circuit is energized or not, allowing electrical firing of the gun

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when the turret is not being traversed or the gun elevated hydraulically. The firing circuits are connected to the gunner's control handle from the filter box through connector (110). Two separate cables leading from the housing are connected to the auxiliary firing station located at the hand-operated hydraulic pump.

- | | |
|---|---|
| A—LIGHT, SIGNAL, ASSY — 7369748 | H—BRACKET, RIGHT, ASSY — 7369414 |
| B—COVER, HOUSING, UPPER — 7369430 | J—RACK, CIRCULAR — 7369332 |
| C—SWITCH, CONTROL, TURRET, ASSY — 7072823 | K—GEAR, SEGMENT, ASSY — 7369376 |
| D—GASKET UPPER HOUSING COVER — 7369673 | L—GRIP, PISTOL, LEFT, ASSY — 7382385 |
| E—BEARING, BALL GRIP — 7382321 | M—NUT, GRIP LOCK — 176334 |
| F—RING, RETAINING, BEARING — 583378 | N—BRACKET, LEFT, ASSY — 7383128 |
| G—GRIP, PISTOL, RIGHT, ASSY — 7369547 | P—HOUSING, CONTROL HANDLE, ASSY — 7369478 |
| | Q—BRACKET, POTENTIOMETER, ASSY — 7369548 |



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Figure 25. Gunner's control handle (covers removed)—front view.

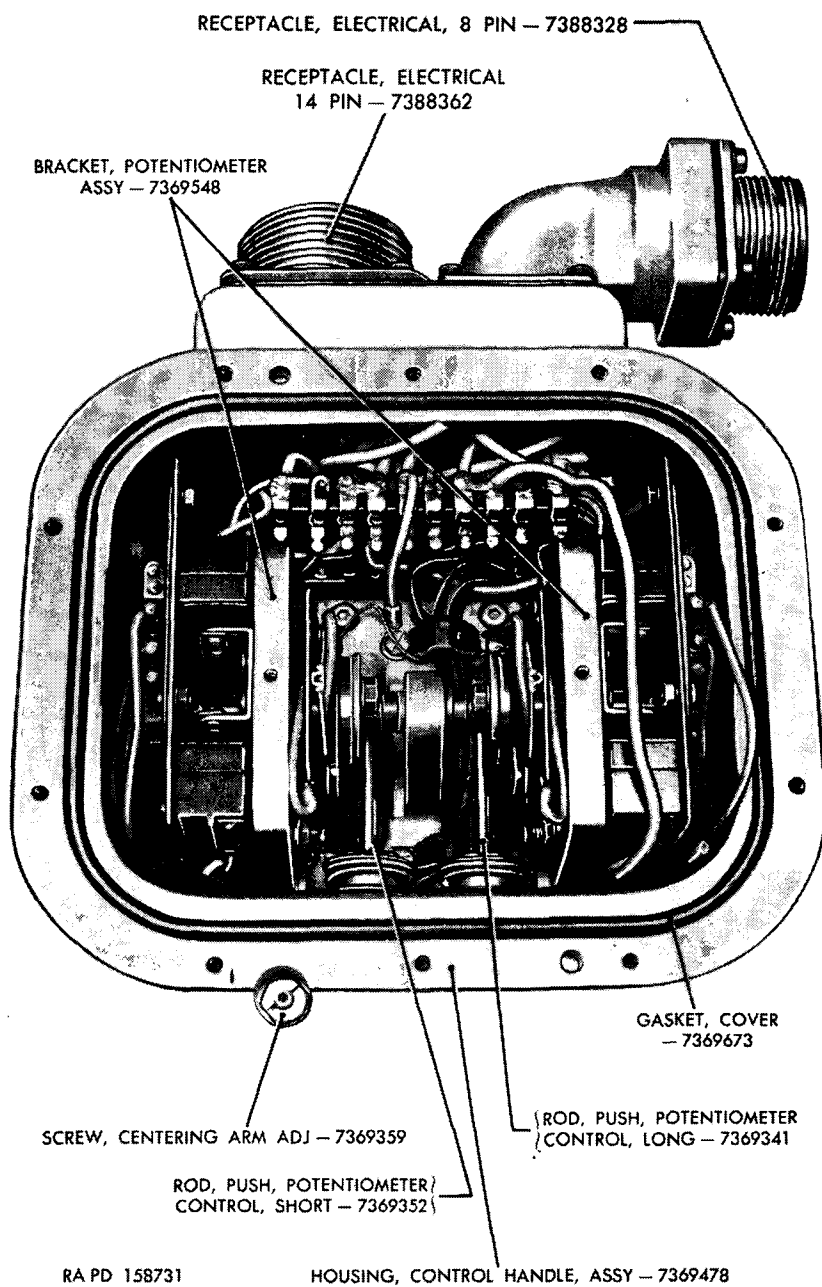


Figure 26. Gunner's control handle (covers removed)—top view.

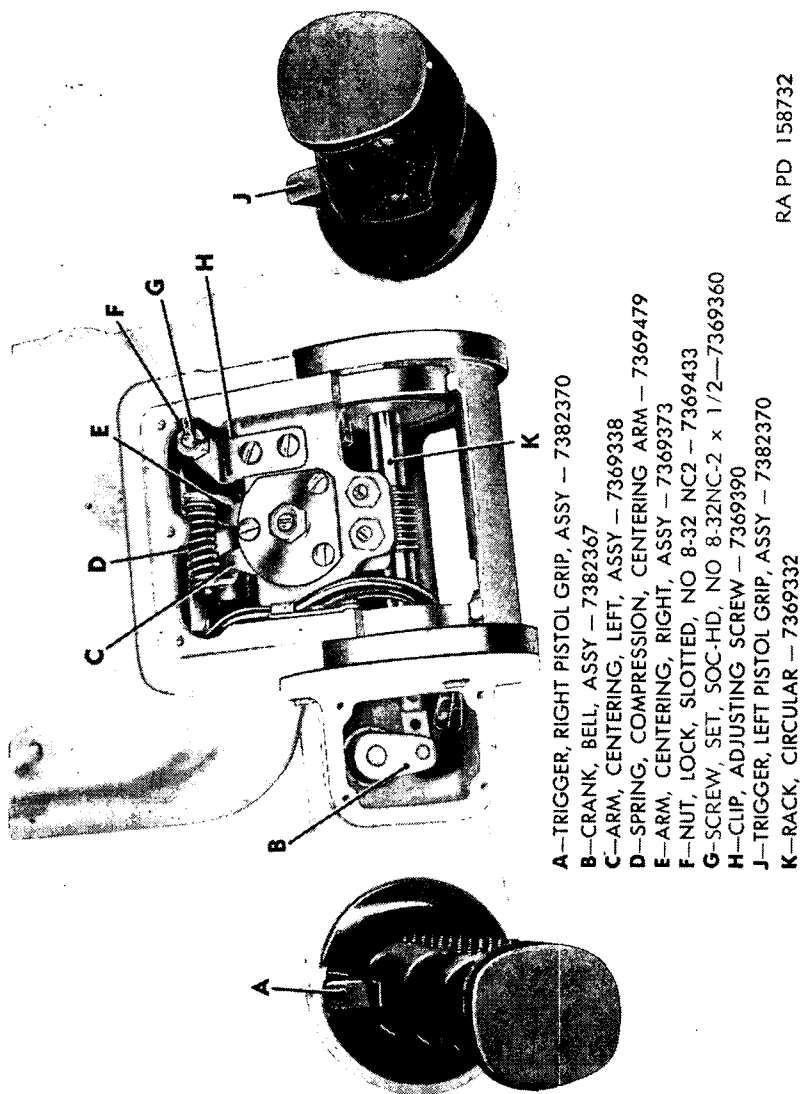
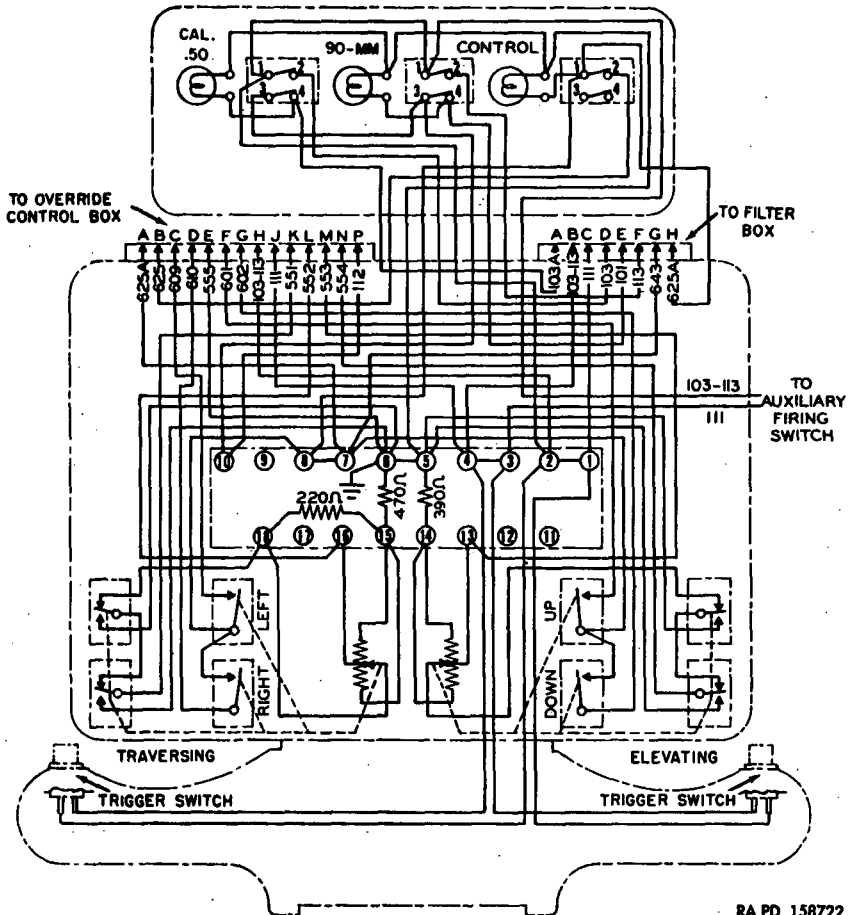


Figure 27. Gunner's control handle (covers removed)—bottom view.

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RA PD 158722

Figure 28. Gunner's control handle—schematic wiring diagram.

d. *Power Elevating* (figs. 24, 25, 26, 27, and 28). Movement of the right pistol grip assembly about the horizontal axis regulates the speed and the direction of movement of the signal motor for the gun-elevating pump control mechanism. By rotating the pistol grip assembly the link which is attached to the right bracket assembly by a pin is given motion. The link converts this rotary motion and transmits it as linear motion to the circular rack which is supported by bearings on each end. Teeth in the circular rack mesh with a segment gear assembly and transmit the motion and convert it to rotary motion. This rotary motion is again converted and transmitted as linear motion to the short potentiometer control push rod by means of a pin. The push rod is connected to the arm assembly on the shaft

assembly of the potentiometer bracket assembly, giving the shaft assembly rotary motion. Rotary motion of the shaft assembly results in several actions being accomplished. The potentiometer contactor slides along the potentiometer and the collector ring thus varying the circuit resistance, one of the two directional micro-switches is actuated, depending upon whether shaft rotation is clockwise or counterclockwise, and as the shaft reaches its rotational limit (30° clockwise or counterclockwise), one of the two slewing micro-switches, depending upon direction of shaft rotation, is actuated to cause the gun elevating mechanism to run at full speed. The pistol grip and its control linkage are returned to a center-neutral position on release of the pistol grip by means of a centering arm spring (fig. 27). The centering arm spring pushes against two centering arm assemblies which force a pin attached to the segment gear assembly to its neutral position. Travel limits of 30° in each direction are defined by milled stops in the control handle housing assembly.

e. Power Traversing (figs. 24, 25, 26, 27, and 28). Movement of the right pistol grip assembly about a vertical axis regulates the speed and direction of movement of the signal motor for the turret traversing pump control mechanism. The left pistol grip assembly is stationary. Rotation of the right pistol grip assembly is transmitted as linear motion to a circular rack through linkage connecting them. A segment gear assembly moved by the circular rack, in turn, moves the short potentiometer control push rod, attached to the shaft assembly of the potentiometer bracket assembly. The actions of the potentiometer bracket assembly are similar to the actions for elevating. Milled stops in the right bracket assembly define the travel limits of 30° in each direction of the pistol grip assembly. Directional micro-switches and slewing micro-switches are provided for traversing the turret which function in a manner similar to those for elevating the gun.

f. Firing (figs. 27 and 28). Firing triggers and trigger switch assemblies are mounted in both the right and left pistol grip assemblies. When either trigger is depressed it pivots about a pin pressed into the pistol grip and forces a lever to trip the trigger switch. The trigger switch closes the firing circuit to the gun. A firing trigger compression spring forces the lever and firing trigger away from the trigger switch when the trigger is released.

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Section IV. OVERRIDE CONTROL BOX

18. Description

(figs. 29, 30, 31, and 32)

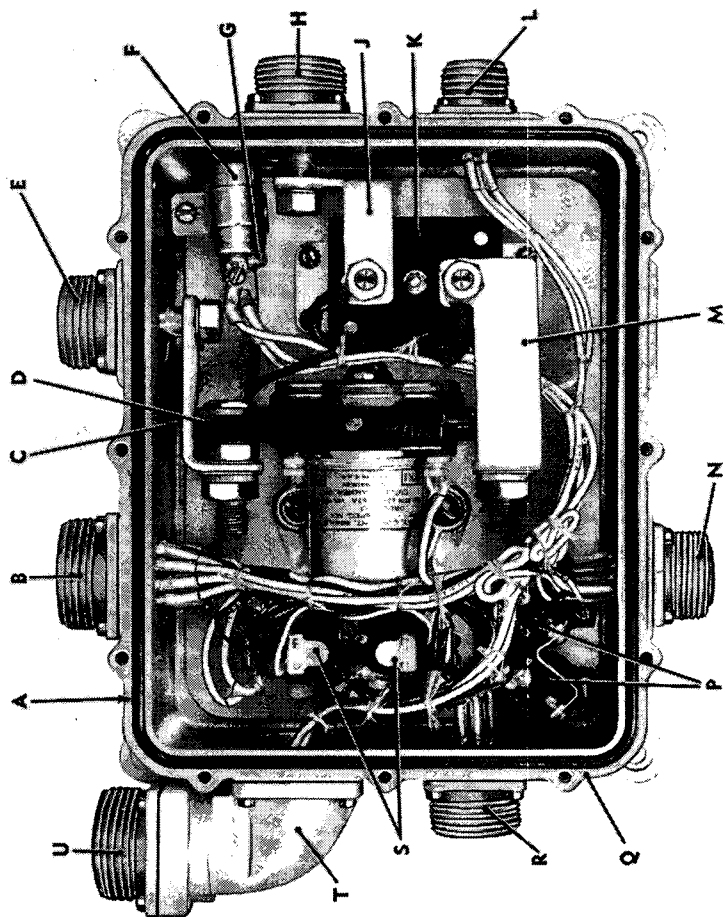
The override control box is a cast aluminum housing with mounting lugs cast as an integral part of the housing. The housing cover is held in place with slotted cap screws and the cover gasket provides a waterproof closure. Around the outside of the control box are located seven waterproof electrical receptacles. The name plate is located on the cover.

Note. There are two types of override control boxes used in the 90-mm Gun Tank M47. The boxes are designated series 1 and series 2. The series 1 override control box (figs. 29 and 30) contains two relays that switch the circuits from the gunner's control handle to the commander's control handle. The series 2 control box (figs. 31 and 32) contains three relays that switch the circuits from the gunner's control handle to the commander's control handle. The two control boxes are interchangeable without affecting the operation of the turret control system.

19. Principles of Operation

(figs. 29, 30, 31, and 32)

a. General. The main function of the override control box is to switch all control and firing circuits from the gunner's control handle to the commander's control handle when the override switch lever on the commander's control handle is depressed. The override control box also acts as the main junction box for the fire control system. All power is obtained from the turret slip ring which is connected through a harness directly to the override control control box. The circuits within the control box distribute the power to the various circuits of the fire control system of the turret. The electric drive motor which drives the hydraulic pumps is powered through the electric drive motor relay and a circuit breaker located in the override control box. All circuits of the pulsing relay system pass through this junction box; therefore, it is possible, by means of relays, to transfer control of the guns and of elevating and traversing from the gunner's control handle to the commander's control handle. This action is provided by relays with multipole, double-throw switching action. The coils of the small relays are connected in parallel and are energized by the override control switch in the pistol grip of the commander's control handle. When the relays are energized, gun control, fire con-



- A-GASKET, COVER - 7382878
 B-RECEPTACLE, ELECTRICAL, 14 CONTACT - 7388363
 C-STRAP, TERMINAL - 7388299
 D-RELAY, ELECTRIC DRIVE MOTOR, CURRENT, 400 AMP, 24 V - 7717664
 E-RECEPTACLE, ELECTRICAL, 1-CONTACT - 7751500
 F-CAPACITOR, 0.10 μ f - 502024
 G-CAPACITOR, 0.25 μ f - 502031
 H-RECEPTACLE, ELECTRICAL, 1-PIN - 7388305
 J-STRAP, TERMINAL - 7388297
 K-BREAKER, CIRCUIT, 200 AMP - 7387301
 L-RECEPTACLE, ELECTRICAL, 3-CONTACT - 7720491
 M-STRAP, TERMINAL - 7388298
 N-RECEPTACLE, ELECTRICAL, 14-CONTACT - 7388325
 P-BREAKER, CIRCUIT, 20 AMP - 7703946
 Q-BOX - 7369445
 R-RECEPTACLE, ELECTRICAL, 8-CONTACT - 7388329
 S-RELAY, FOUR POLE, DT, 5 AMP, 24 V - 7383173
 T-ELBOW, ELECTRICAL RECEPTACLE - 7716691
 U-RECEPTACLE, ELECTRICAL, 14-CONTACT - 7388363

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Figure 29. Series 1 override control box—cover removed.

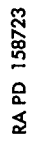


Figure 30. Series 1 override control box—schematic wiring diagram.

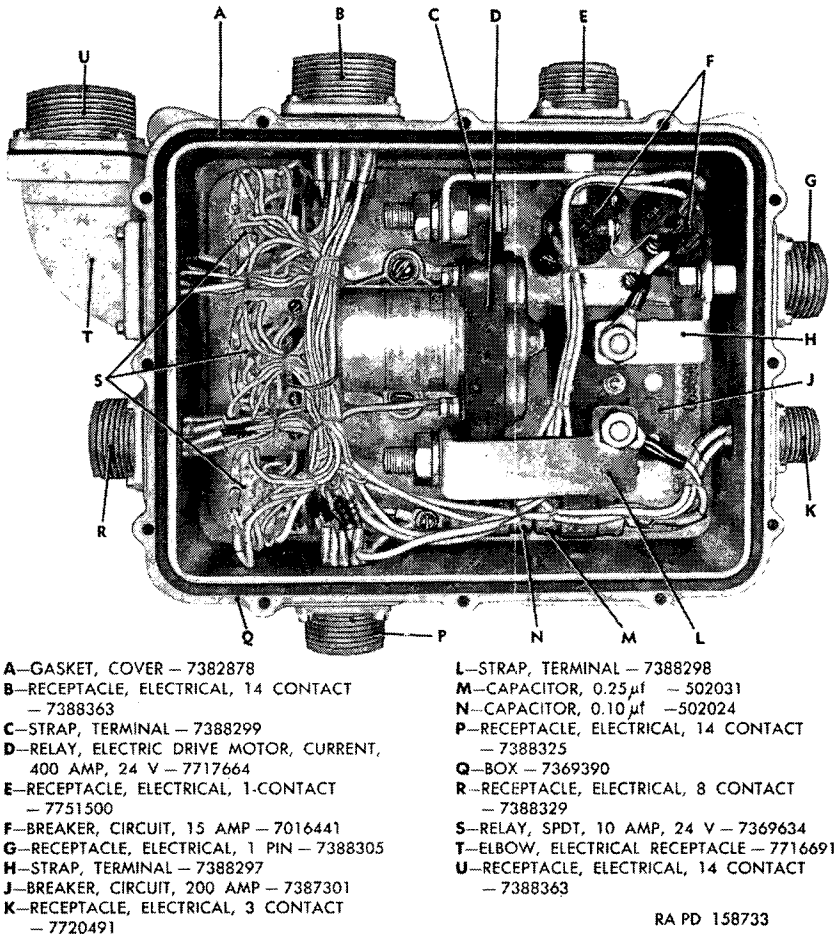


Figure 31. Series 2 override control box—cover removed.

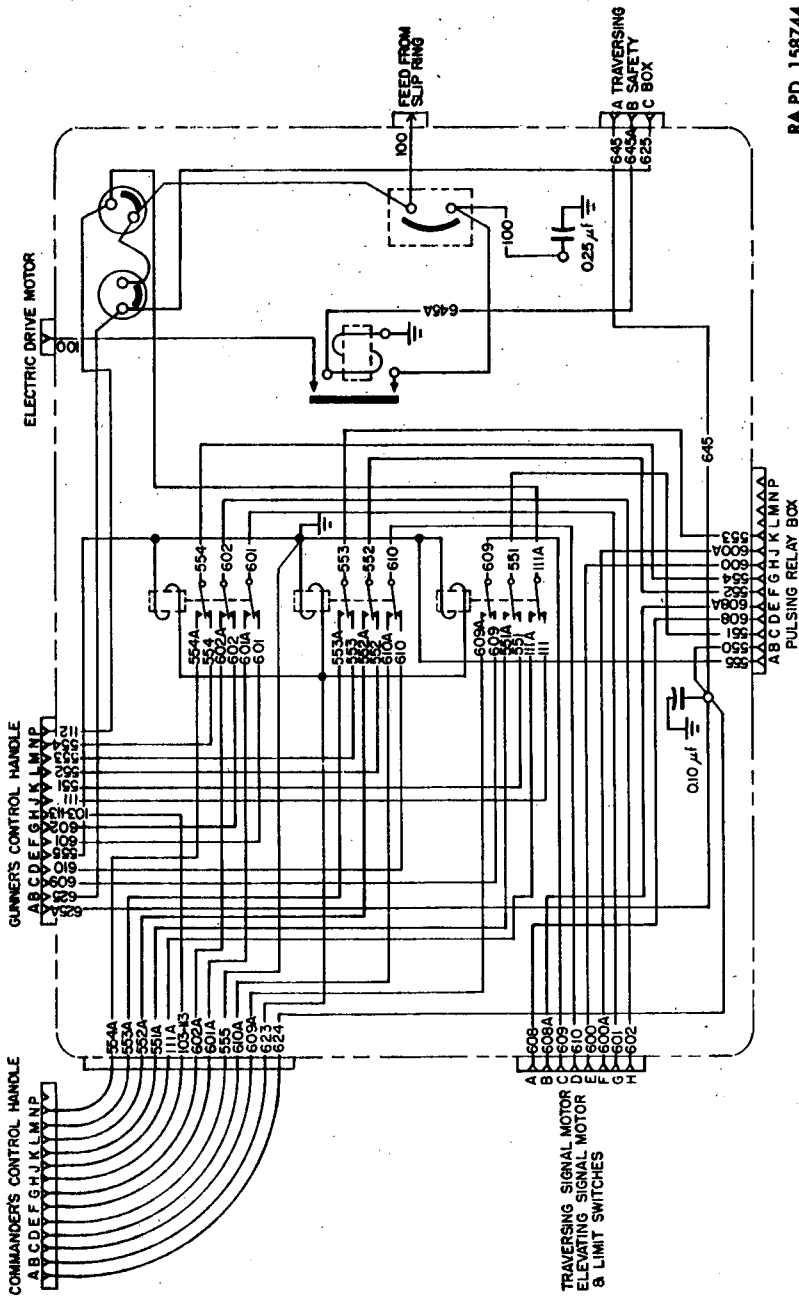


Figure 32. Series 2 override control box—schematic wiring diagram.

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trol and elevating and traversing control circuits are switched from the gunner's control handle to the commander's control handle.

b. Data.

Electric drive motor relay :

Current..... 100 amperes

Voltage..... 24 volts

Override relay :

Current..... 5 amperes

Voltage..... 24 volts

Electric drive motor circuit breaker :

Current..... 200 amperes

Control circuit breaker :

Current..... 20 amperes

Section V. PULSING RELAY BOX

20. Description

(figs. 33 and 34)

The pulsing relay box is a cast aluminum housing with mounting lugs cast as an integral part of the housing. The housing cover is held in place with special, slotted head cap screws and the cover gasket provides a waterproof closure. On the outside of the box is mounted a waterproof electrical receptacle. The box contains the two electrical chassis mounting the pulsing relays and the electrical components required to complete the pulsing relay circuits.

21. Principles of Operation

(figs. 33 and 34)

a. General. The pulsing relay control box is the speed controlling element in the turret control system. The pulsing relay control box functions with the gunner's and commander's control handles to provide two channels of control, one for elevating and one for traversing. The pulsing relay control box, functioning in conjunction with the gunner's or commander's control handles, regulates the speed of the signal motors. The pulsing relay control system is designed to work into a double field, reversible, series-wound d-c motor. Signal motor speed is regulated by the angular displacement of the potentiometer contractor in the control handles; and direction of rotation upon the operation of the motor field selecting micro-switches, also in the control handles. Operation of the pulsing relay control system depends upon pulsing relays of the polarized type in which current flow

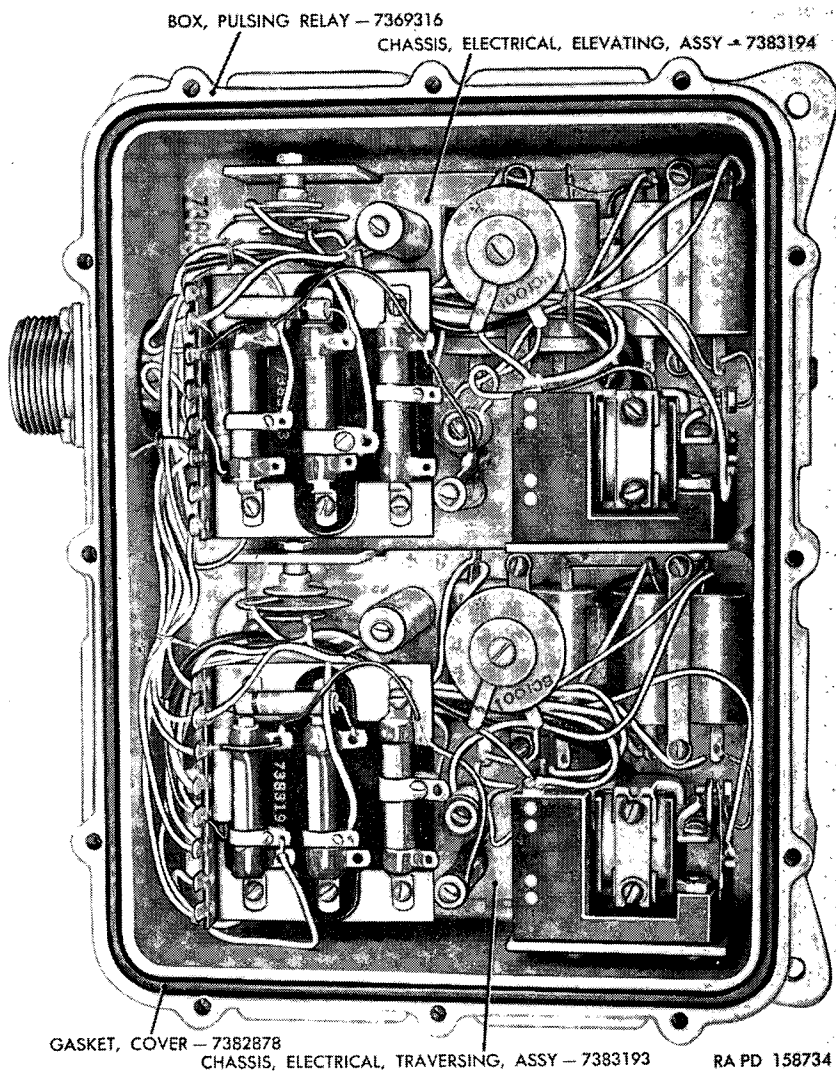
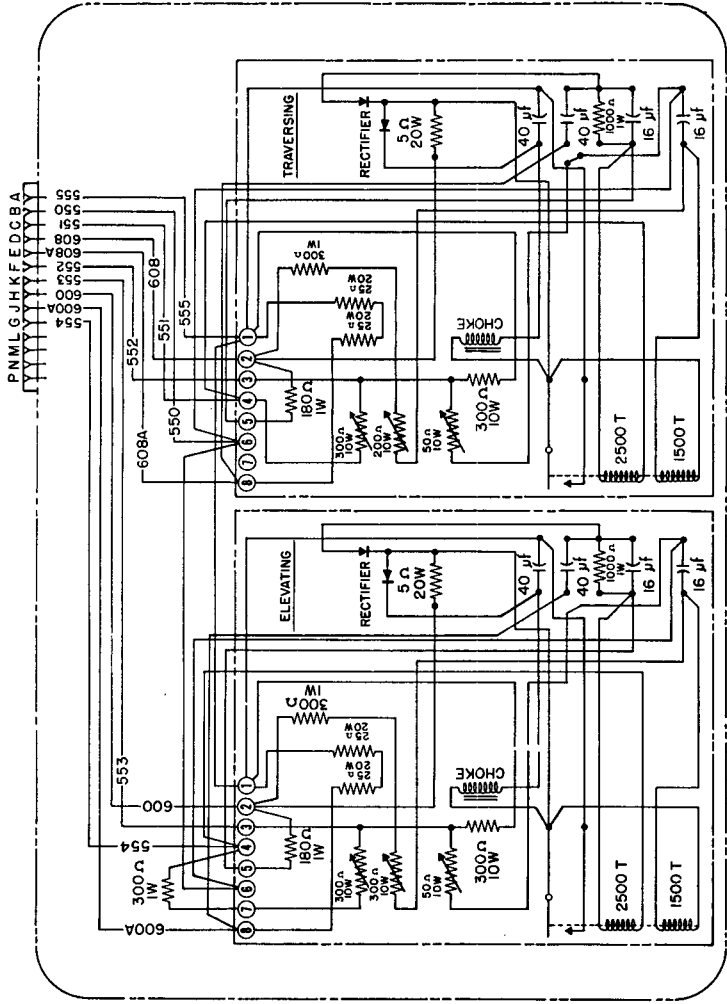


Figure 33. Pulsing relay box—cover removed.

in one direction closes the relay contacts and current flow in the opposite direction opens the contacts. The pulsing relay employs a single set of make-and-break contacts which control the current flow through the signal motor field and armature. Actual speed regulation of the signal motor is achieved by pulsing these contacts, varying the percentage of closed time during each cycle. Two separate coil

TO OVERRIDE CONTROL BOX



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Figure 34. Pulsing relay box—schematic wiring diagram.

windings are used on the relay, one functioning as a speed selector winding and the other as a speed regulator winding. Current flow in the speed selector winding is controlled mainly by a speed control potentiometer in the control handles. Current in the speed regulator winding is controlled mainly by the back emf developed in the motor armature. When the control handle is rotated sufficiently to cause the current in the speed selector winding to be great enough to overcome the polarizing flux in the relay, the relay contacts close and the signal motor is momentarily energized. Simultaneously with the closing of the contacts, the voltage differences across the various components in the circuit shift in such a manner that a reverse current is caused to flow through the speed selector winding, tending to open the relay contacts. This results in the continuous pulsing action, which has little or no effect on regulation of the motor speed for varying load conditions. To obtain the extremely low signal motor speeds which are required at times, two capacitors, a rectifier, and various resistors are added to the pulsing relay circuit.

b. Data.

Nominal input voltage, dc.....	26 volts
Maximum relay contact current, at 30 vdc.....	4 amperes
Relay coil closing current.....	5 ± 0.3 milliamperes
Relay coil opening current.....	1 ± 0.3 milliamperes
Pulses to produce one revolution of signal motor (at minimum speed, minimum)	60

Section VI. SIGNAL MOTORS

22. Description

(figs. 35 and 36)

Two signal motors are used in the pulsing relay system, one for the traversing pump control mechanism and the other for the elevating pump control mechanism. Each signal motor is a series-wound, direct current motor, with two field windings. The motor is contained in a cast aluminum housing with a six-hole mounting flange that is bolted directly to the upper control housing of the hydraulic pump control mechanism. An electrical receptacle is mounted on the housing for connection to the rest of the system.

23. Principles of Operation

(figs. 35 and 36)

a. General. Each of the two signal motors responds to signals from the pulsing relay control box to control the output of the hy-

A—PLATE, END, MOTOR — 7383164
 B—GASKET, END PLATE — 7383167
 C—HOUSING, MOTOR — 7383165
 D—CAP, BRUSH, ASSY — 7369464
 E—PLUG, RETAINING, BRUSH — 7369461
 F—BRUSH — 7369460
 G—BEARING, BALL — 7369471
 H—HOUSING, W CABLE, BRUSH, ASSY — 7369459
 J—GASKET, ELECTRICAL RECEPTACLE — 7383168
 K—WASHER, LOCK, NO 6 — 138526
 L—SCREW, RD-HD, NO 6-32 x 3/8 — 132696

M—RECEPTACLE, ELECTRICAL, ASSY — 7524938
 N—PLATE, NAME — 7369516
 P—SCREW, RD-HD, NO 2-56 x 1/8 — 421550
 Q—FIELD, W CABLE, ASSY — 7369452
 R—SCREW, FL-HD, NO 6-32 x 2 — 100813
 S—WASHER, LOCK, NO 6 — 138589
 T—ARMATURE, W COMMUTATOR, ASSY — 7369470
 U—BEARING, BALL — 7369477
 V—NUT, HEX, NO 10-32—MHR — 16930-19
 W—GEAR, DRIVE, MOTOR — 7383166
 X—RING, RETAINING, BEARING — 583009

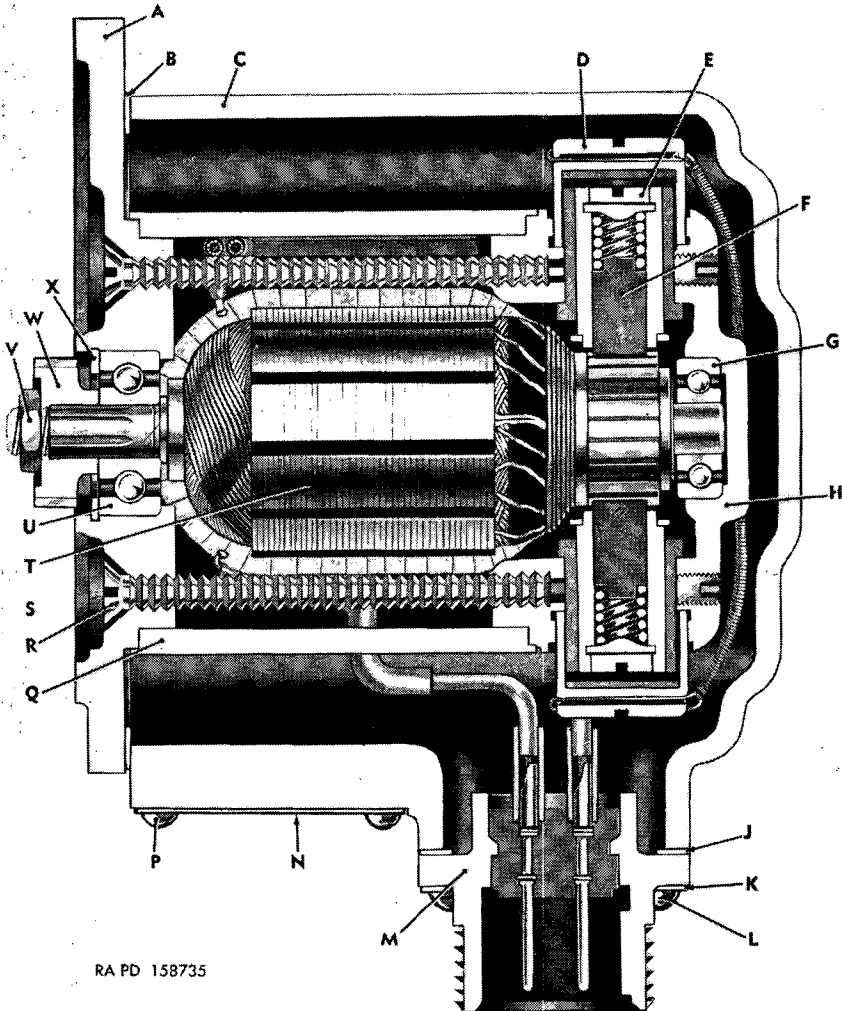
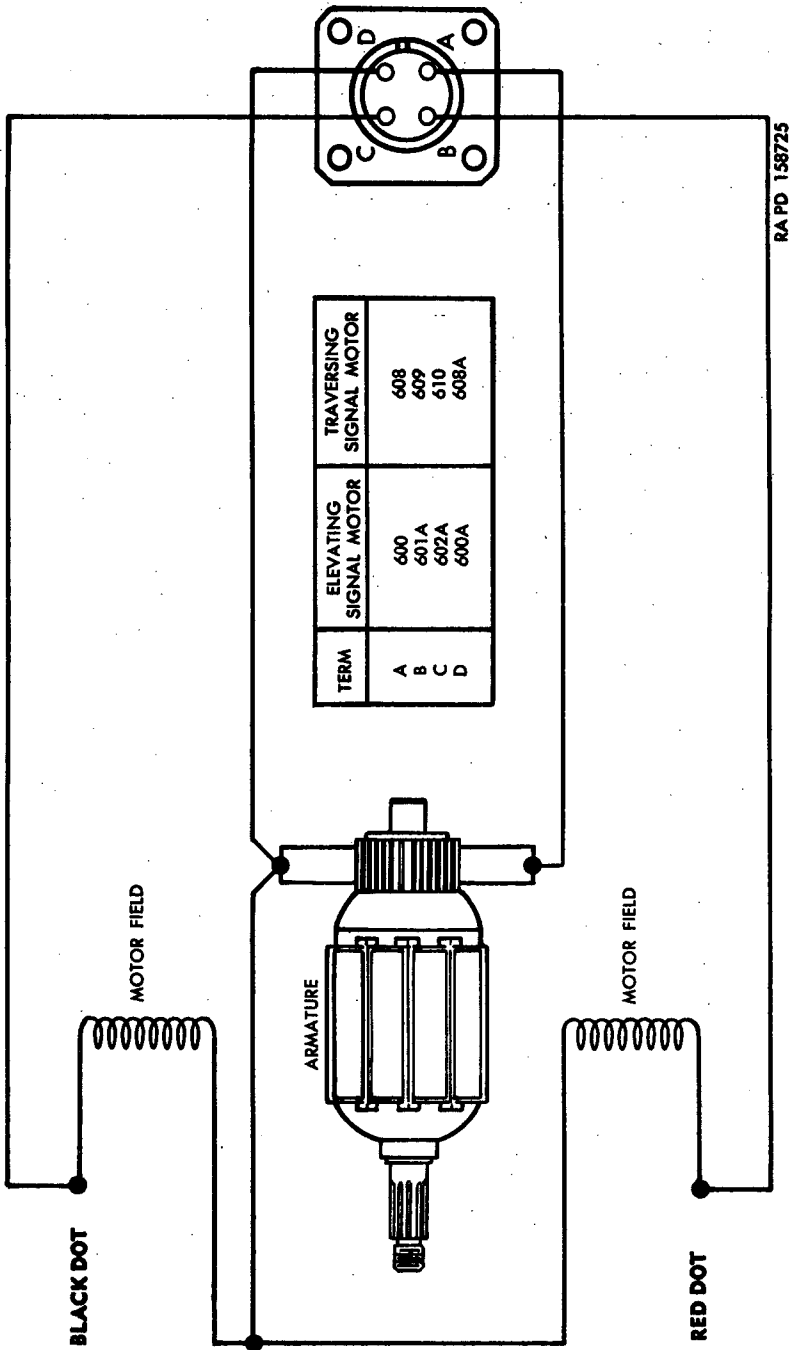


Figure 35. Signal motor—cross section.



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Figure 36. Signal motor—schematic wiring diagram.

draulic pump for each of the two axes. The pulsing relays in the elevating and traversing electrical chassis (fig. 33) cause the signal motor to run in either direction at any speed up to the maximum as selected by the gunner or the crew commander. The signal motors move the slide blocks in the hydraulic pumps through the pump control mechanisms, causing them to deliver oil to the hydraulic system. The displacement of the slide blocks from neutral position in the hydraulic pumps will determine the speed at which the hydraulic motor will turn and/or the speed at which the elevating cylinder will operate. The signal motor responds to signals from the pulsing relay control box to control the operation of the hydraulic pumps. The common connection between the two signal motor fields and one of the brushes is brought out through a resistor in the pulsing relay control box so that the field is across the line in series with the resistor. Refer to figure 19. The armature also is in series with the field and another smaller resistor. This provides a combination series and shunt connections. In operation, one or the other of the field windings is energized when one of the directional switches in the gunner's (or commander's) control handle is closed. The speed of the motor is then determined by the percentage of closed time of the pulses received from the pulsing relays. When a slewing switch is closed the power to the motor armature becomes continuous and the motor runs at maximum speed.

b. Data.

Nominal input voltage, dc.....	26 volts
Nominal free speed with maximum signal.....	12,000 rpm
Nominal stalled torque with maximum signal.....	11 ounce-inches
Nominal brush life with average pulsing.....	500 hours

Section VII. LIMIT SWITCHES

24. Description

(fig. 11)

The limit switches are two micro-switches contained in separate cast aluminum water-resistant housings. The housings are connected by a cast aluminum mounting bracket. There is an electrical receptacle and harness mounted on each switch housing. An arm is cast on the side of the mounting bracket and contains a ball and socket, through which a switch actuating push rod moves. There are two adjusting screws with locking nuts mounted on the push rod for adjusting the travel limits of the gun.

25. Principles of Operation

(figs. 3, 11, and 12)

a. General. The switch actuating push rod moving in the mounting bracket is connected to the 90-mm gun and controls the elevating and depressing limits of the gun. When the gun is elevated, the push rod is moved downward, sliding in the ball and socket. As the gun approaches the end of its travel the upper adjusting screw contacts a lever pivoted about a pin pressed into the limit switch mounting bracket. The lever presses against the elevating limit switch to actuate the switch, opening the elevating circuit and stopping the signal motor, and thereby stopping the gun. The action is similar when the gun is depressed except that the depressing limit switch is actuated.

b. Data.

Over-all length, w/harness	22½ inches
Weight	4¼ pounds
Rated voltage:	
At 3 amperes, ac	0.460 volt
At 5 amperes, ac	0.250 volt
At 10 amperes, ac	0.125 volt
Adjustment (each adjusting screw, maximum)	¾ inch

CHAPTER 4

HYDRAULIC SYSTEM

Section I. DESCRIPTION AND PRINCIPLE OF OPERATION

26. Description

a. General (fig. 37). The hydraulic turret-traversing and gun-elevating system consists essentially of a traversing mechanism with hydraulic motor drive, differential shifting piston, and power traversing bypass valve; a power pack with hydraulic filter which supplies controlled fluid power for both power turret-traversing and power gun-elevating or gun-depressing an elevating cylinder, a selector valve, a bypass safety valve, a check valve, a locking valve, a dump valve, a hand-operated elevating pump, a hand-operated supercharge pump, an accumulator, a power elevating bypass valve, a supercharging valve, an equalizing valve, an accumulator drain valve and hydraulic lines.

b. Gunner's Manual-Traversing (fig. 37). The gunner's manual-traversing system consists essentially of an inclosed gear train with a differential, a no-back mechanism and bevel gear drive from a control handle to the right front of the gunner's seat. Manual traversing of the turret can be performed with or without the power pack in operation, while the gun is idle or while the gun is manual or power elevated or depressed. A solenoid-hydraulic operated dump valve mounted in the hydraulic lines close to the traversing mechanism automatically directs the gear pump oil to the differential shifter piston and the neutral lock plunger when the power pack is started. When the release lever on the gunner's manual traversing control handle is squeezed, the dump valve solenoid micro-switch is actuated and the dump valve solenoid is energized. The dump valve solenoid quickly opens the dump valve to drop the pressure behind the differential shifting piston in the traversing mechanism to permit the spring to engage the manual drive gears and simultaneously lower the plunger in the power traversing bypass valve to bypass the oil delivered by the traversing pump. Simultaneously, the dump valve also drops the pressure behind the neutral lock plunger to permit the spring to raise the neutral lock


plunger and move the traversing eccentric control shaft to neutral position.

c. *Gunner's Hydraulic Manual-Elevating or Depressing* (fig. 37). The hydraulic manual gun-elevating and gun-depressing system consists essentially of a hand-operated elevating pump with a check valve assembly and a locking valve assembly, a selector valve, hydraulic swivel joints; a bypass safety valve, an elevating cylinder, an accumulator, a hand-operated supercharge pump, a power elevating bypass valve, a supercharge valve, an equalizing valve, and an accumulator drain valve connected through hydraulic lines and fittings to the power pack. Hydraulic manual elevating or depressing of the gun can be performed with or without the power pack in operation, while the turret is idle or while the turret is manual or power traversed. The gunner's hand-operated elevating pump is bolted to the bottom of the gunner's power traversing and elevating control box and both the check valve and locking valve assemblies are fastened to the hand-operated elevating pump. To the right of the power pack and bolted to the turret is the selector valve. The hydraulic swivel joints and the bypass safety valve are directly below the gun and the clevis and trunnion mounted elevating cylinder is to the right of the gun. Clamped to a bracket to the right of the power pack is the accumulator. Although the hand-operated supercharge pump is fastened to the turret floor to the right of the gunner's seat, the hand-pump handle is to the left of the gunner's seat. The supercharge valve which is closed during manual elevating of the gun is directly in front of the selector valve. The equalizing valve which is opened when initially charging the elevating system is directly behind the gunner's power-traversing-and-elevating-control handle. The power elevating bypass valve which is opened during manual elevating of the gun is directly below the selector valve. The accumulator drain valve used to drain the hydraulic system is fastened to a bracket near the turret floor and to the right of the power pack.

d. *Gunner's or Commander's Hydraulic Power Traversing* (figs. 60, 61, and 62). The hydraulic power turret-traversing system consists essentially of a power pack (hydraulic traversing pump, hydraulic elevating pump, hydraulic filter, oil reservoir and electric drive motor), a traversing mechanism, a hydraulic motor, a power traversing bypass valve, no-back lock and a dump valve connected through hydraulic lines and fittings. A vertically-mounted electric motor, bolted to the drive gear case, drives the traversing pump and the elevating pump at constant speeds through gears. The traversing pump shaft rotates counterclockwise and the elevating pump shaft rotates clockwise, when viewed from ends of drive shafts. Both

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pumps are bolted to the drive gear case and to the oil reservoir. Taps in the oil reservoir and the electric motor receive bolts for fastening the power pack to the turret. The hydraulic motor and power traversing bypass valve are mounted integral with the traversing mechanism. Hydraulic lines convey the oil to and from the power pack, hydraulic motor, dump valve, power traversing bypass valve and differential shifting piston in the traversing mechanism.

c. Gunner's or Commander's Hydraulic Power Elevating or Depressing (figs. 64, 65, and 66). The hydraulic power gun-elevating and gun-depressing system consists essentially of a power pack (hydraulic elevating pump, hydraulic traversing pump, hydraulic filter, oil reservoir and electric drive motor (*d* above), and the hydraulic manual-elevating components (*c* above). A high grade light oil is used as the fluid power medium in the hydraulic power turret-traversing and gun-elevating systems.

27. Principle of Operation

a. General. Manual turret-traversing and gun-elevating mechanisms enable gunner to traverse or train the turret and elevate or depress the gun in case of power failure or damage to the power traversing or power elevating systems. Hydraulic power turret-traversing and hydraulic power gun-elevating mechanisms enable both the gunner and the commander to traverse or train the turret and elevate or depress the gun quickly and accurately with a minimum of effort. The commander may override the gunner.

b. Gunner's Manual Traversing. Refer to paragraph 5.

c. Gunner's Manual Elevating or Depressing. Refer to paragraph 5.

d. Gunner's or Commander's Hydraulic Power Traversing (figs. 60, 61, and 62). Controlled fluid power for training and traversing turret quickly and accurately is supplied by a two-way, variable-delivery, radial piston hydraulic pump mounted in the power pack and driven by the electric drive motor. This pump delivers oil in either direction through two hydraulic lines to a constant-displacement hydraulic motor mounted on the traversing mechanism. Built into the traversing pump is a constant-delivery gear pump which discharges all of its oil through a hydraulic filter, supercharges the radial piston traversing hydraulic pump and the radial piston traversing hydraulic motor system, supplies fluid power to the control pistons in the traversing pump and actuates the differential shifting piston in the traversing mechanism to close the power traversing bypass valve. Two pistons of a four-piston supercharged hydraulic dither pump, built into the elevating pump, alternately withdraw oil from and inject oil into the traversing system at a rapid rate to create pulsa-

tions of pressure. These pulsations maintain an intermittent high pressure in the traversing system and set up vibrations in certain movable parts in the hydraulic motor and traversing mechanism so that the hydraulic motor shaft can respond instantly to the demands of the control. Another piston of the dither pump provides a similar action on the large control piston and slide block assembly in the traversing pump. Any volume of oil up to maximum is delivered in either direction by the hydraulic traversing pump in response to a differential control mounted on the hydraulic traversing pump. A small electric signal motor drives the first leg of the differential, a feed-back gear and cable from the turret drives the second leg of the differential and dual opposed hydraulic servo-motor pistons move pump slide block assembly in response to the third leg of the differential. Both the speed and direction of electric signal motor operation is selected by the degree and direction of movement of the gunner's control handle or commander's control handle. The commander may override the gunner. Releasing control handles or moving them back to neutral position stops turret movement. This controlled drive traverses the turret continuously in either direction, at any speed up to maximum, through a traversing mechanism and a ring gear. It permits rapid traverse for following a fast moving target. It permits quick reversal for changing targets. It permits slow rotation in either direction for following a stationary or moving target when tank is in motion, a moving target when tank is stationary or when gunner is making fine adjustments on telescopic sights. Characteristics inherent in the hydraulic turret traversing mechanism are—high frequency alternating pulsations in hydraulic lines to permit instantaneous hydraulic motor response to demands of the control and to move the turret to and hold it at a desired position without overtravel; continuously variable speed control in either direction with a minimum of effort; rapid acceleration or deceleration in either direction; hydro-dynamic braking; automatic protection against overloading drive mechanism; pressure and flood lubrication of all working parts in the hydraulic traversing pump and the hydraulic motor with the oil in the system.

c. Gunner's or Commander's Hydraulic Power-Elevating and Depressing (figs. 64, 65, and 66). Controlled fluid power for elevating and depressing the gun quickly, smoothly and accurately is supplied by a two-way, variable-delivery, radial piston hydraulic pump mounted in the power pack and driven by the electric drive motor. This pump delivers oil in either direction through two hydraulic lines and a selector valve to a nondifferential, double-ram, clevis and trunnion mounted elevating cylinder. Filtered oil from the constant-

delivery gear pump, built into the traversing pump, supercharges the radial piston elevating hydraulic pump and the elevating cylinder system; it supplies fluid power to the control pistons in the elevating pump; and it actuates and holds the selector valve plungers in the power operation positions. Any volume of oil up to maximum is delivered in either direction by the hydraulic elevating pump in response to a differential control mounted on the elevating pump. A small electric signal motor drives the first leg of the differential, a spring-loaded cable from the gun drives the second leg of the differential and dual opposed hydraulic servo-motor pistons move the pump slide block assembly in response to the third leg of the differential. The first leg of another differential in the same control is driven by an automatic range finder. The second and third legs of this differential operate identically to the signal motor driven differential. Both the speed and direction of the electric signal motor operation is selected by the degree and direction of movement of the gunner's control handle or the commander's control handle. The commander may override the gunner. Releasing control handles or moving them back to neutral position stops elevating or depressing of gun. Power elevation permits rapid elevating or depressing and quick reversal of movement for changing targets. It permits slow elevating or depressing of gun for following a stationary or moving target when tank is in motion, a moving target when tank is stationary or when gunner is making fine adjustments on telescopic sights. Characteristics inherent in the power elevating mechanism are—continuously variable elevating or depressing speed with a minimum of effort; rapid acceleration or deceleration for elevating or depressing; hydro-dynamic braking; automatic protection against overloading elevating mechanism; pressure and flood lubrication of all working parts in the elevating pump, selector valve and elevating cylinder with the oil in the system.

Section II. POWER PACK

28. Construction

a. General. The power pack (figs. 38 and 39) consists essentially of an electric drive motor, a drive gear case to inclose the drive gears, a traversing pump (Oilgear Model AT-411) with a signal motor (Minneapolis-Honeywell Model G-2059A1) and feed back operated differential control, an elevating pump (Oilgear model ATT-411) with a signal motor or range finder and feed back operated dual differential control, an oil reservoir and a hydraulic filter.

b. Electric Drive Motor (figs. 40 and 41). The entire turret-traversing and gun-elevating system is powered by the electric drive

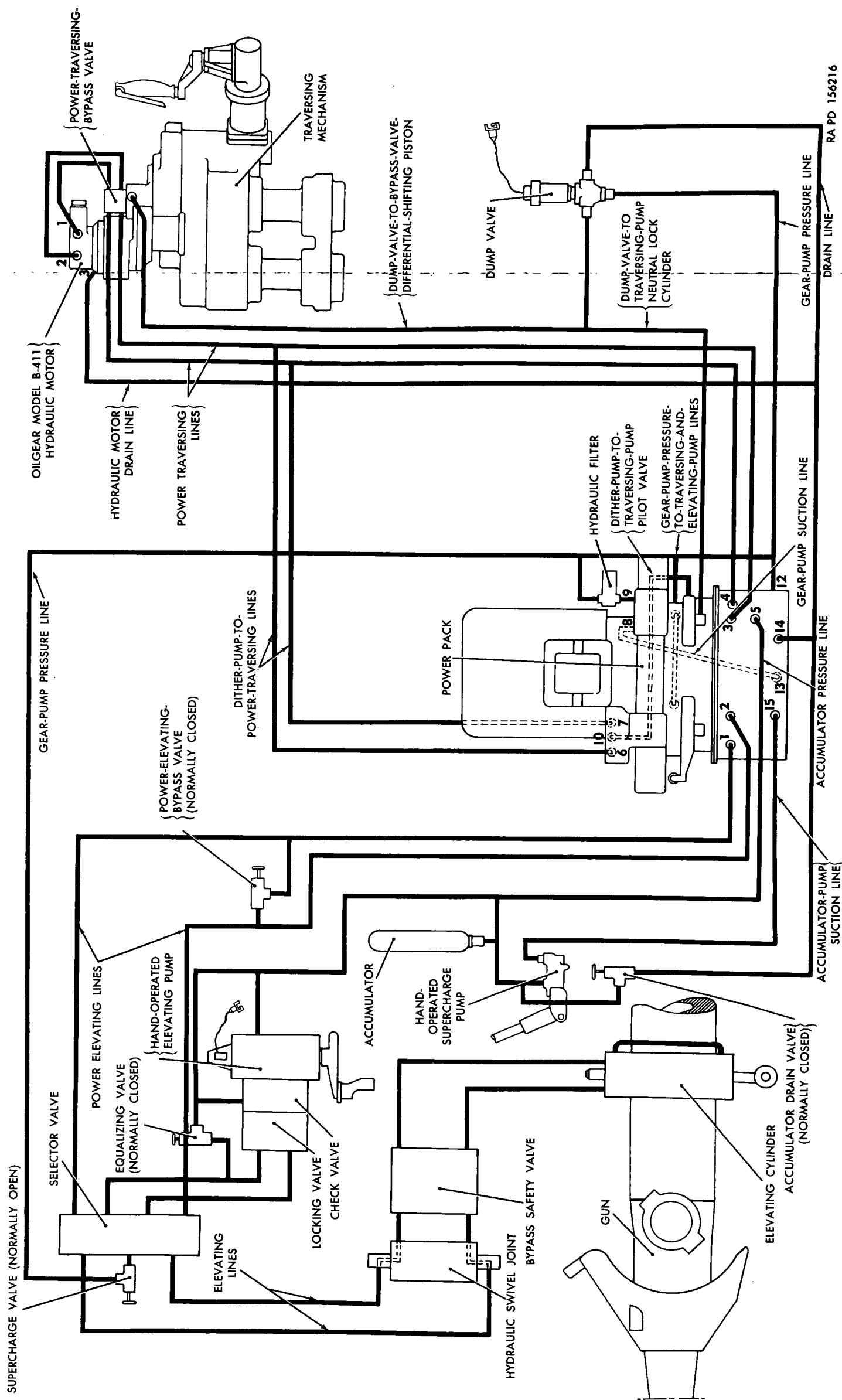


Figure 37. Turret-traversing and gun-elevating system—schematic oil circuit diagram.

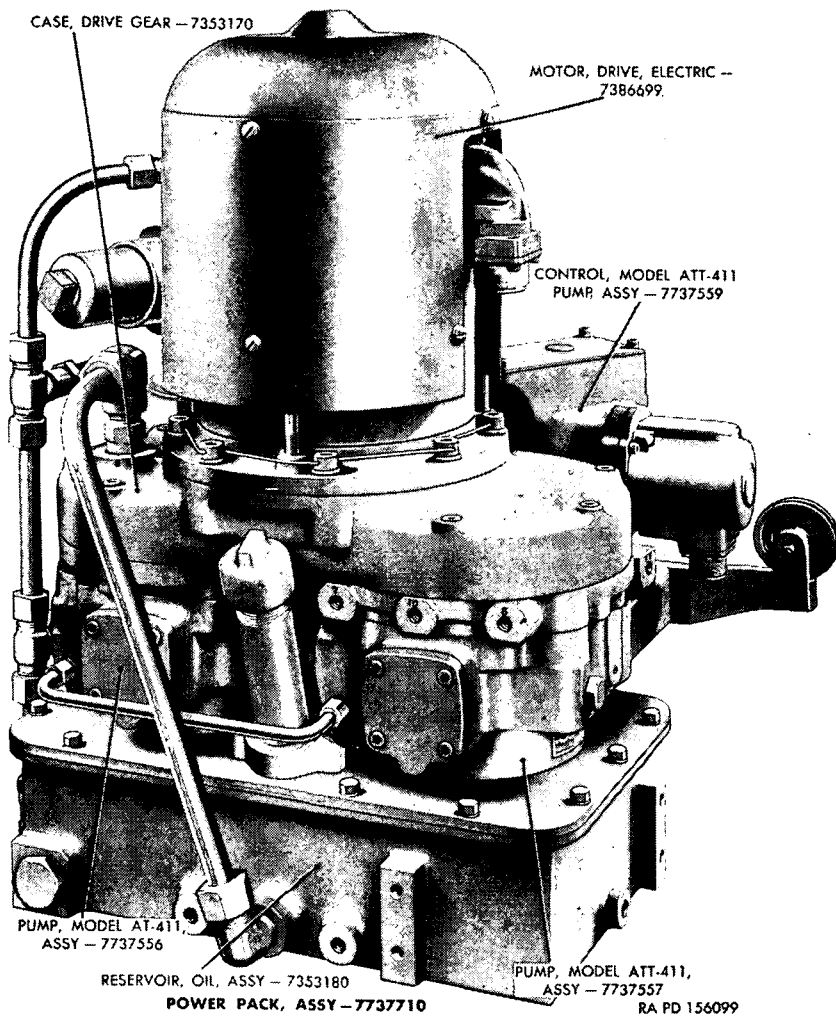


Figure 38. Power pack—front view.

motor (A. O. Smith Model D-9004). The motor is a compact, fully-inclosed, sealed motor which is resistant to water and dirt. It is vertically mounted on the top of the power pack (fig. 38). The motor is inclosed with covers which act as ducts for the cooling air circulated (fig. 40) by the external fan (fig. 41). Air is drawn through the apertures in the external fan cover (fig. 40) near the center of the external fan (fig. 41) and forced by the fan between the motor frame and the main cover (fig. 40) until it is expelled to the atmosphere near

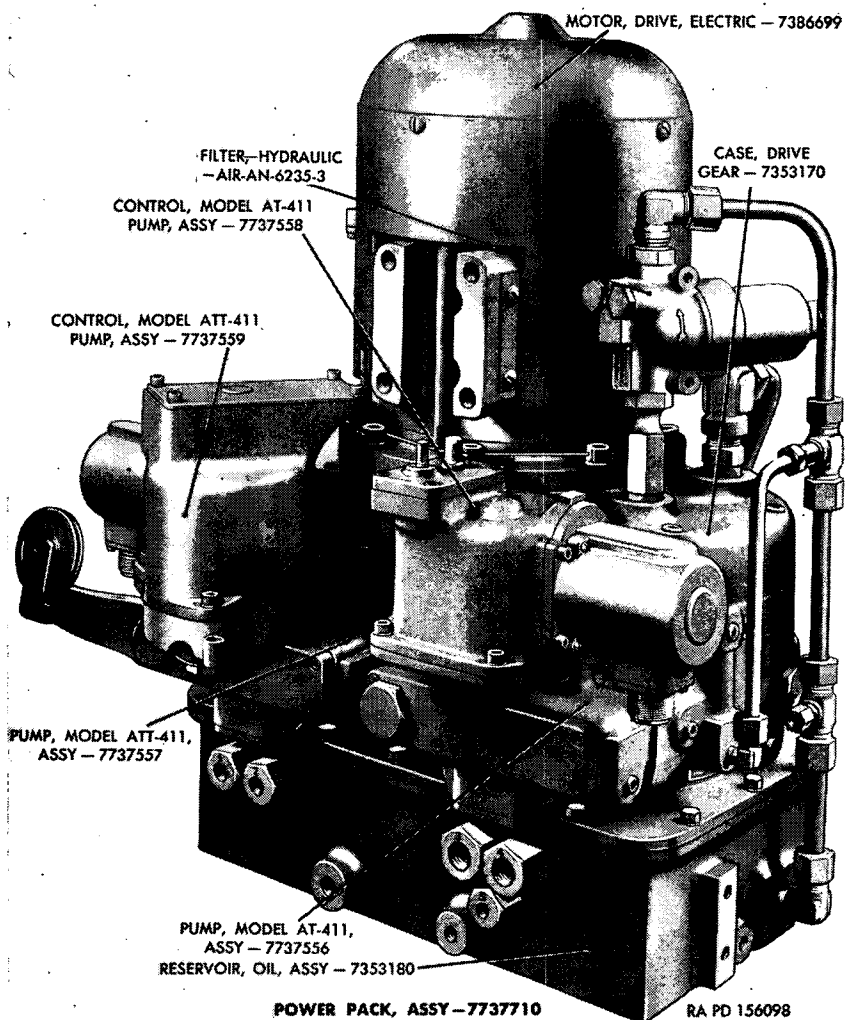


Figure 39. Power pack—rear view.

the lower end of the motor (fig. 40), effectively cooling the motor externally. An internal fan (fig. 41) attached to the armature shaft (fig. 41) draws air through the space between the armature and field coils assemblies and forces the air to return between the field coil windings to the commutator end of the armature (fig. 41). This internal circulation of air prevents the formation of local "hot spots" within the motor and assists the transfer of heat to the motor frame where it is dissipated to the air circulated by the external fan (fig. 41).

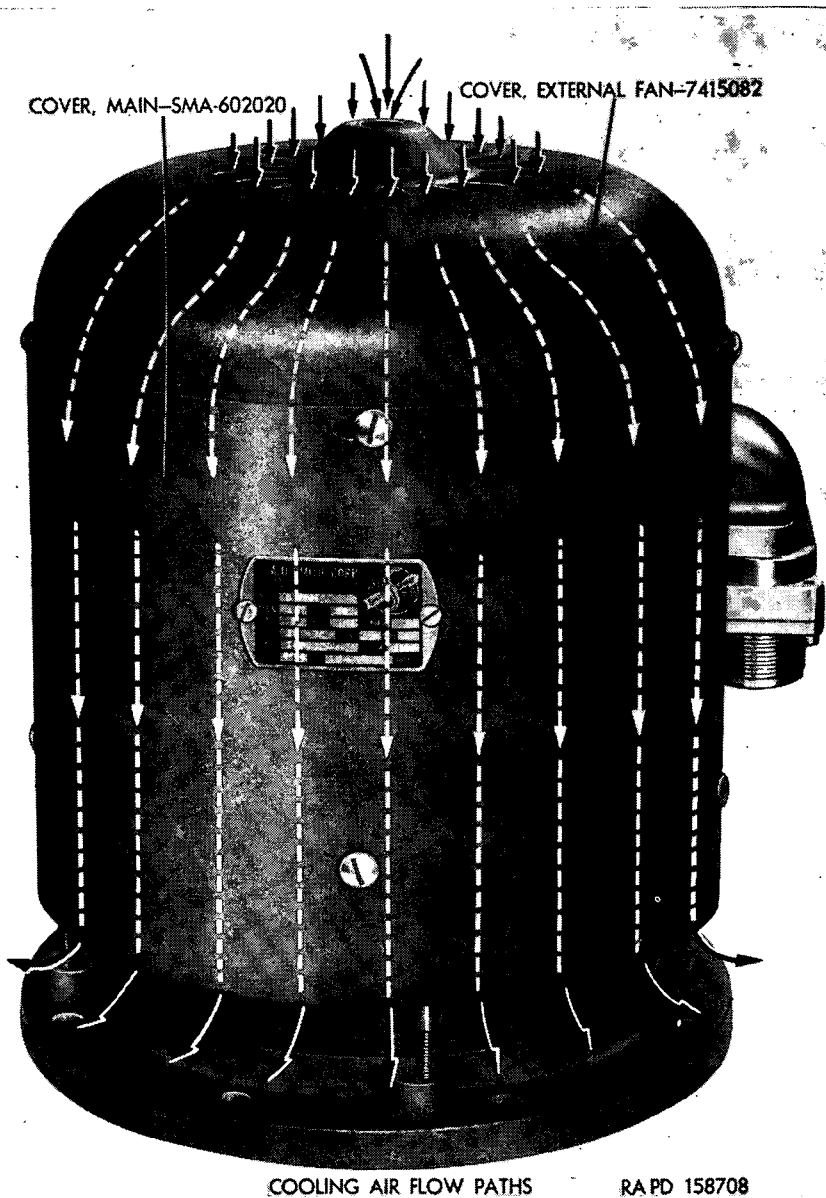
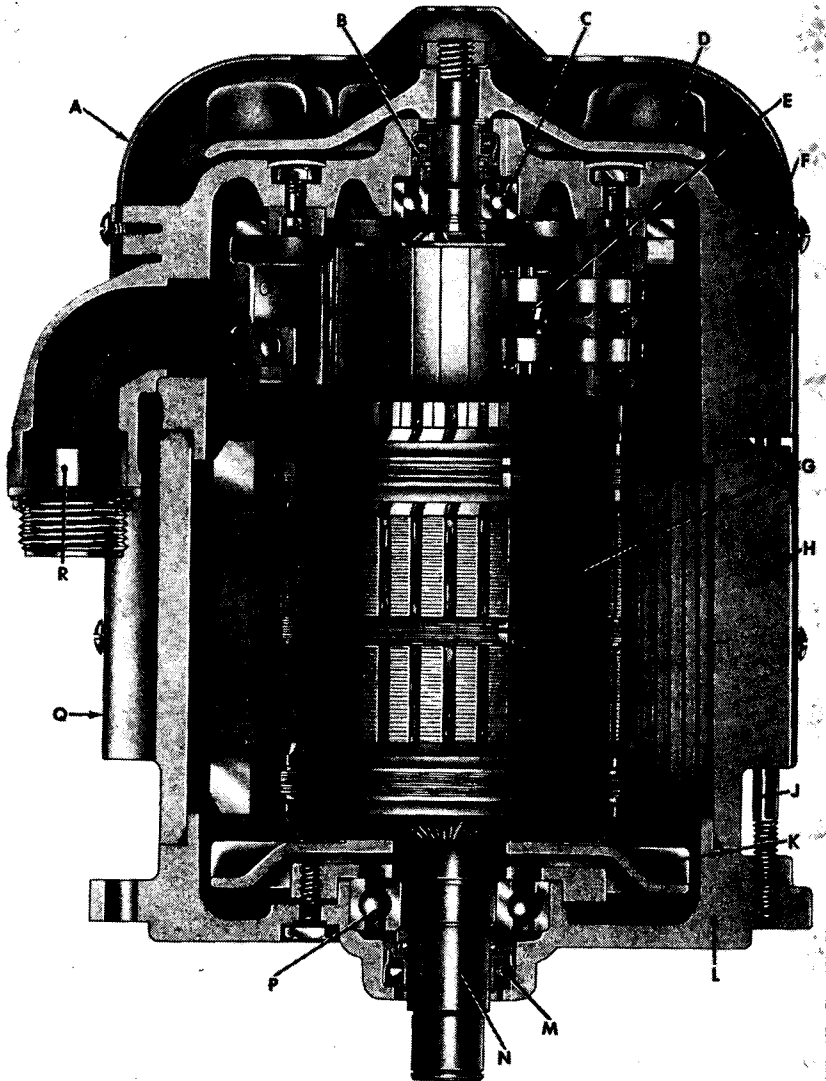


Figure 40. Electric drive motor—cooling air flow.

c. *Drive Gear Case* (figs. 48 and 54). The drive gear case encloses the electric drive motor gear, traversing-pump idler gear, traversing-pump drive gear and elevating-pump drive gear. It provides flange



- A—COVER, EXTERNAL FAN-7415082
- B—SEAL, OIL, COMMUTATOR END, ASSY-7414742
- C—BEARING, ARMATURE SHAFT, COMMUTATOR END-700157
- D—FAN, EXTERNAL-7415081
- E—HOLDER, BRUSH-SMA-605002
- F—HEAD, COMMUTATOR END-SMA-400138
- G—ARMATURE, W/INTERNAL FAN, ASSY-7414710
- H—FRAME, W/FIELD COILS, ASSY-SMA-303021

- J—(BOLT, THROUGH, 5/16-24NF-2 x 6-1/8-7414714)
- K—FAN, INTERNAL
- L—HEAD, DRIVE END-SMA-400137
- M—SEAL, OIL, DRIVE END, ASSY-7374219
- N—SHAFT, ARMATURE
- P—BEARING, ARMATURE SHAFT, DRIVE END-700070
- Q—COVER, MAIN-SMA-602020
- R—RECEPTICLE, ASSY-7388320

RA PD 158707

Figure 41. Electric drive motor—cross section.

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mounting for the electric drive motor and flange mounting for the traversing and elevating pumps.

d. *Traversing Pump (Oilgear Model AT-411)* (figs. 37 and 38).

(1) *Upper control mechanism* (figs. 42, 43, and 44). The upper control mechanism consists of a fractional horsepower, direct

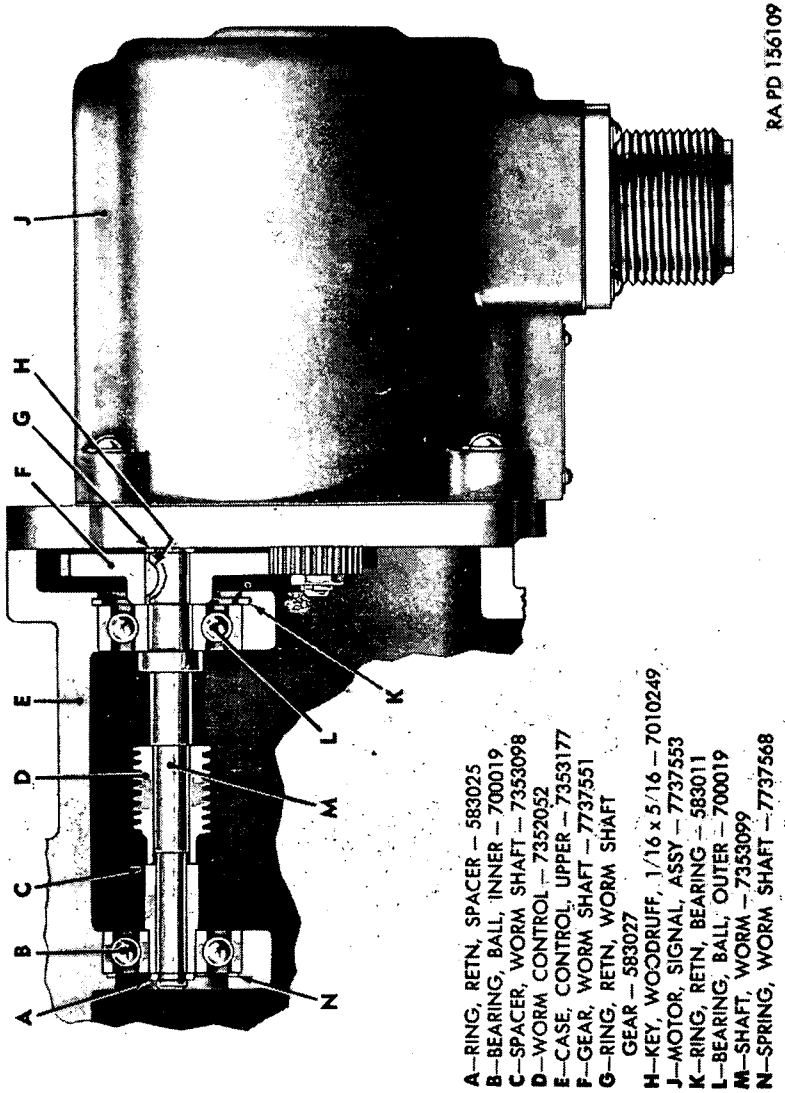


Figure 42. Signal motor and worm gear drive—cross section.

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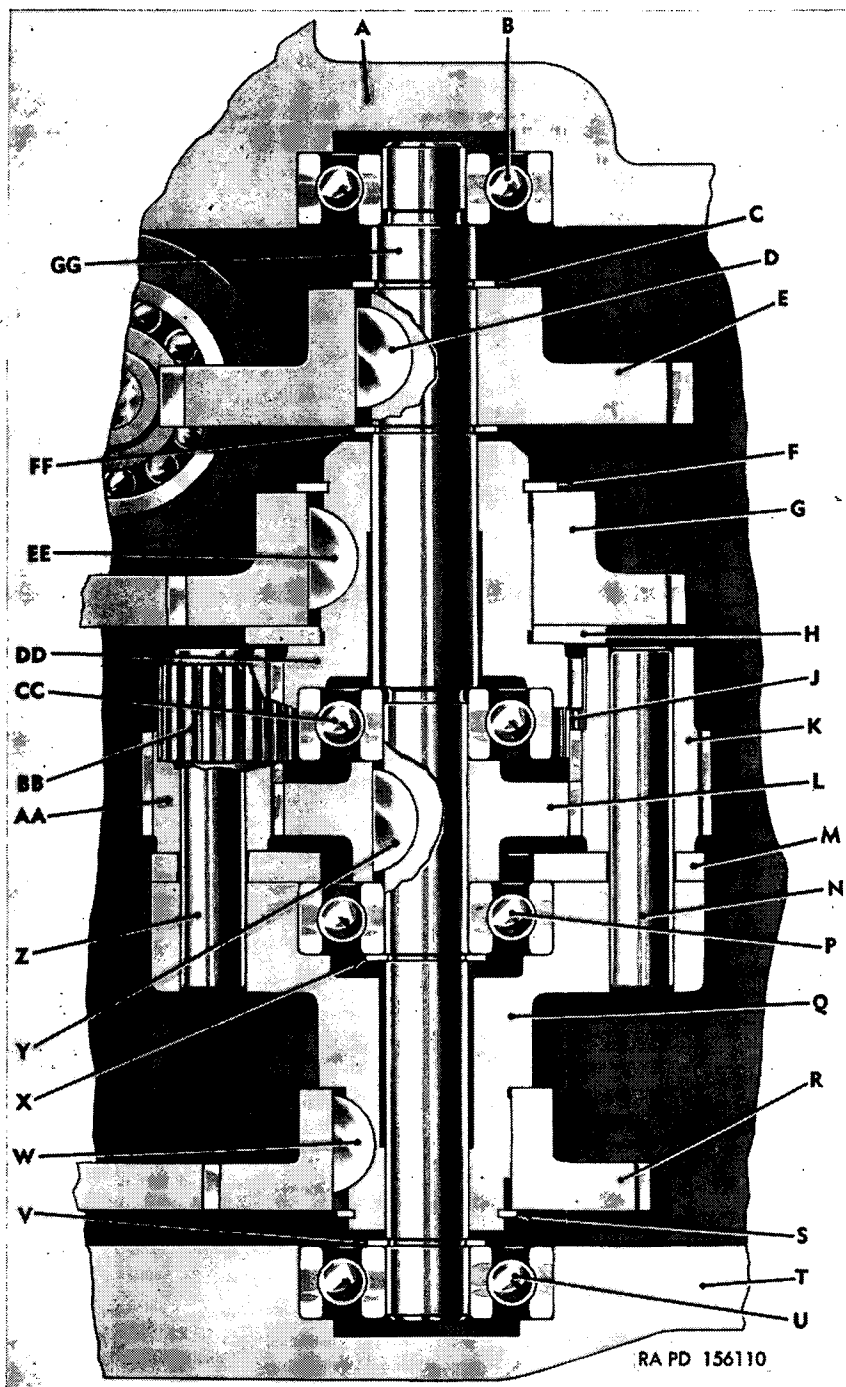


Figure 43. Differential and differential input gear—cross section.

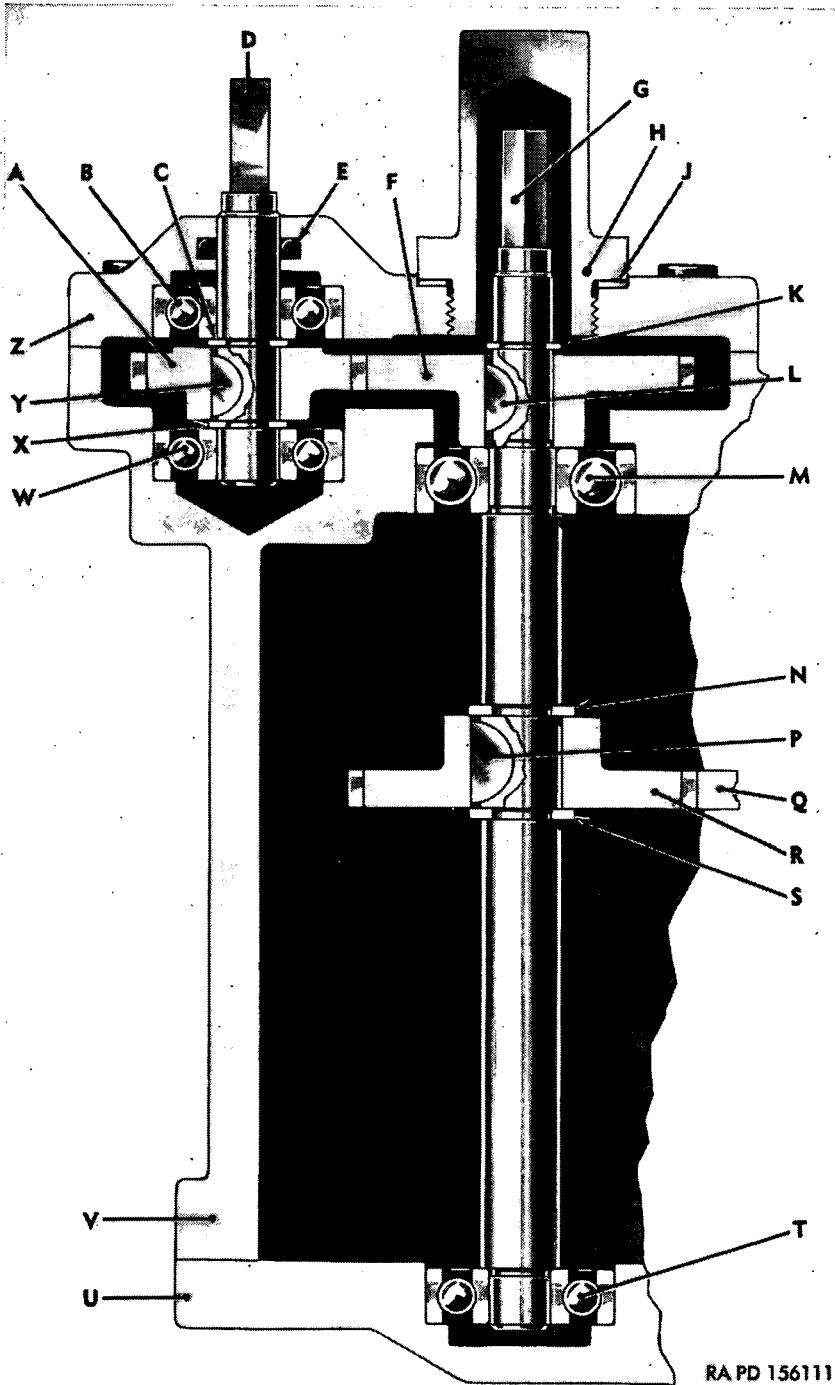
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Figure 43--Continued.

A--CASE, CONTROL, UPPER--7353177
B--BEARING, BALL, UPPER--700016
C--RING, RETN, DIFFERENTIAL INPUT GEAR, UPPER--583029
D--KEY, WOODRUFF, $\frac{1}{16} \times \frac{1}{16}$, (DIFFERENTIAL INPUT GEAR)--7010239.
E--GEAR, INPUT, DIFFERENTIAL--7352053
F--RING, RETN--583037
G--GEAR, DIFFERENTIAL FEED--BACK INPUT--7353058
H--WASHER--7737574
J--GEAR, PLANETARY, UPPER--7737572
K--GEAR, PLANETARY, LOWER--7737572
L--GEAR, SUN, LOWER--7737571
M--RETAINER, LOWER SUN GEAR BEARING--7737573
N--PIN, DOWEL, 0.1876--0.1878 DIAM $\times$ 1
P--BEARING, BALL, LOWER SUN GEAR--700016
Q--CARRIER, OUTPUT GEAR, DIFFERENTIAL--7737578
R--GEAR, OUTPUT, DIFFERENTIAL--7737515
S--RING, RETN, OUTPUT GEAR--583034
T--CASE, CONTROL, LOWER--7353172
U--BEARING, BALL, LOWER--700016
V--RING, RETN--583027
W--KEY, WOODRUFF, $\frac{1}{16} \times \frac{1}{16}$ --7010239
X--RING, RETN, 583027
Y--KEY, WOODRUFF, $\frac{1}{16} \times \frac{1}{16}$, (LOWER SUN GEAR)--7010239
Z--PIN, DOWEL, 0.1876 -- 0.1878 DIAM $\times$ 1
AA--GEAR, PLANETARY, LOWER--7737572
BB--GEAR, PLANETARY, UPPER--7737572
CC--BEARING, BALL, UPPER SUN GEAR--700016
DD--GEAR, SUN, UPPER--7010230
EE--KEY, WOODRUFF, $\frac{1}{16} \times \frac{1}{16}$, (FEED-BACK GEAR)--7010239
FF--RING, RETN, DIFFERENTIAL INPUT GEAR, LOWER--583029
GG--SHAFT, DIFFERENTIAL--7737577

current, variable speed, reversible electric signal motor assembly (Minneapolis-Honeywell model G-2059A1) with four connecting white leads (fig. 42). The signal motor assembly is fastened to the upper control case. Connecting leads are soldered to a flanged-type electrical connector receptacle. A signal motor shaft gear splined and locked to the signal motor shaft meshes with a worm shaft gear keyed to the worm shaft. A control worm pressed on the worm shaft meshes with a differential input gear keyed to the differential shaft (fig. 43). The differential shaft is mounted on two antifriction upper and lower ball bearings. The lower sun gear, keyed to the differential shaft and resting on the lower sun gear bearing, meshes with the two lower planetary gears mounted on hardened and ground dowel pins pressed into the

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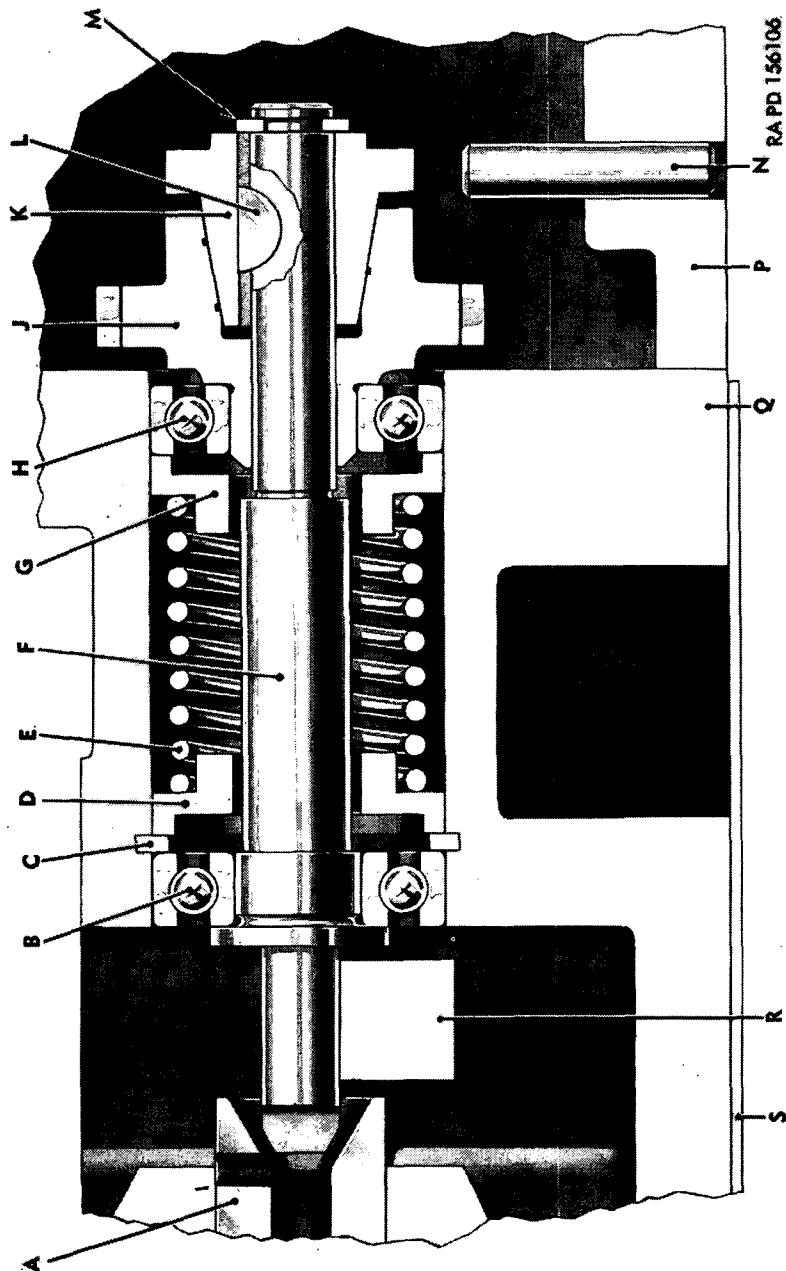
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Figure 44. Traversing input feedback and auxiliary input feedback shafts—cross section.

Figure 44—Continued.

A—GEAR, AUX FEEDBACK—7352022
B—BEARING, BALL, AUX FEEDBACK SHAFT, UPPER—700016
C—RING, RETN, AUX FEEDBACK GEAR, UPPER—583027
D—SHAFT, AUX FEEDBACK—7352054
E—GASKET, "O" RING, AUX FEEDBACK SHAFT—7352004
F—GEAR, FEEDBACK SHAFT, UPPER—7352056
G—SHAFT, FEEDBACK—7353148
H—CAP, SHAFT, FEEDBACK—7737552
J—WASHER, LOCK (1.071 - 1.053 OD, 0.659 - 0.640 ID, 0.045 THK)
K—RING, RETN, UPPER FEEDBACK GEAR—583027
L—KEY, WOODRUFF, $\frac{1}{16} \times \frac{5}{16}$ (UPPER FEEDBACK GEAR)—7010239
M—BEARING, BALL, FEEDBACK SHAFT, UPPER—700019
N—RING, RETN, LOWER FEEDBACK GEAR, UPPER—583029
P—KEY, WOODRUFF, $\frac{1}{16} \times \frac{5}{16}$ (LOWER FEEDBACK GEAR)—7010239
Q—GEAR, DIFFERENTIAL FEEDBACK INPUT—7352058
R—GEAR, FEEDBACK SHAFT, LOWER—7352057
S—RING, RETN, LOWER FEEDBACK GEAR, LOWER—583029
T—BEARING, BALL, FEEDBACK SHAFT, LOWER—700016
U—CASE, CONTROL, LOWER—7353172
V—CASE, CONTROL, UPPER—7353177
W—BEARING, BALL, AUX FEEDBACK, LOWER—700016
X—RING, RETN, AUX FEEDBACK GEAR, LOWER—583027
Y—KEY, WOODRUFF, $\frac{1}{16} \times \frac{5}{16}$ (AUX FEEDBACK GEAR)—7010239
Z—COVER, CONTROL CASE, UPPER—7352055

differential output gear carrier. The two upper planetary gears, mounted on hardened and ground dowel pins pressed into the differential output gear carrier, mesh with the upper sun gear which is free to rotate on the differential shaft and the upper sun gear ball bearing. Two planetary gears on each side of the upper and lower sun gears mesh with each other. A bearing retainer for the lower sun gear ball bearing is fastened to the differential output gear carrier with four socket-head screws and lock washers. A differential feedback input gear is keyed to the upper sun gear and meshes with the lower feedback shaft gear keyed to the traversing feedback shaft (fig. 44). An input feedback shaft gear on the traversing feedback shaft meshes with an auxiliary feedback shaft. Both the traversing and auxiliary feedback shafts are mounted on antifriction upper and lower ball bearings. The output traversing differential gear, keyed to the differential output gear carrier, meshes with the traversing clutch gear which is part of the lower traversing control mechanism. A dowel pin, pressed into upper control case which encloses the above mechanism, limits the angular movement of the clutch limit plate.



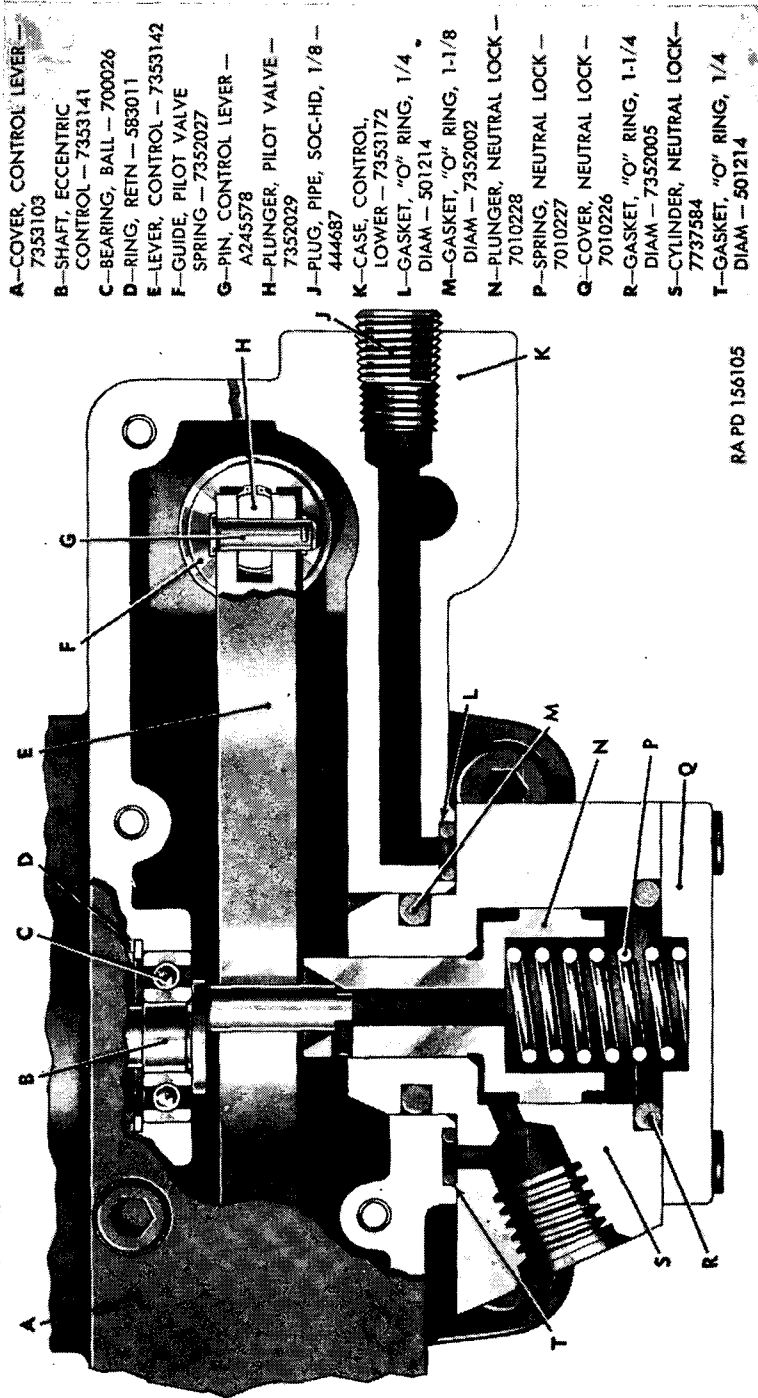
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Figure 45. Traversing control eccentric shaft and clutch—cross section.

Figure 45—Continued

A—PLUNGER, NEUTRAL LOC.—7010228
B—BEARING, BALL, LOWER—700026
C—RING, RETN, GUIDE—583011
D—GUIDE, CLUTCH SPRING—7352026
E—SPRING, SLIP CLUTCH—7353116
F—SHAFT, ECCENTRIC, CONTROL—7353141
G—GUIDE, CLUTCH SPRING—7352026
H—BEARING, BALL, UPPER—700026
J—GEAR, SLIP CLUTCH—7010236
K—PLATE, CLUTCH LIMIT—7352030
L—KEY, WOODRUFF, $\frac{1}{16}$, $\frac{1}{16}$ —7010239
M—RING, RETN, PLATE—583027
N—PIN, DOWEL—A244981
P—CASE, CONTROL, UPPER—7353177
Q—CASE, CONTROL, LOWER—7353172
R—LEVER, CONTROL—7353142
S—GASKET, CONTROL COVER—7353134

- (2) *Lower control mechanism* (figs. 45, 46, and 47). A clutch limit plate is keyed to the traversing control eccentric shaft and confined on the top with a plate retaining ring (fig. 45). A slip clutch spring confined between a fixed clutch spring guide and a floating clutch spring guide, an upper ball bearing and traversing clutch gear, loads the traversing clutch gear onto the clutch limit plate and holds the traversing control eccentric shaft and the lower ball bearing in place. A spring-loaded neutral lock plunger is closely fitted to the neutral lock cylinder and mounted directly below the eccentric stub on the traversing control eccentric shaft (fig. 46). The pilot valve plunger spring between the pilot valve bushing and the pilot valve spring guide removes the play between the pilot valve plunger and the control lever, holds the control lever tight against the eccentric stub on the traversing control eccentric shaft and the socket-head set screw on one end of the control lever tight against the follow-up pin assemblies (fig. 47). Two guide pins pressed into the lower traversing control case, guide the control lever. Pilot valve plunger is closely fitted to the pilot valve bushing which is inserted into the traversing pump case and held in place by an external retaining ring.
- (3) *Radial piston pump* (figs. 47 and 48). The hydraulic traversing pump consists essentially of a stationary, balanced, traversing-pump flat valve; a ported traversing-pump shaft with 14 radial cylinders having closely fitted rolling pistons; a slide block assembly with a piston reaction ball bearing



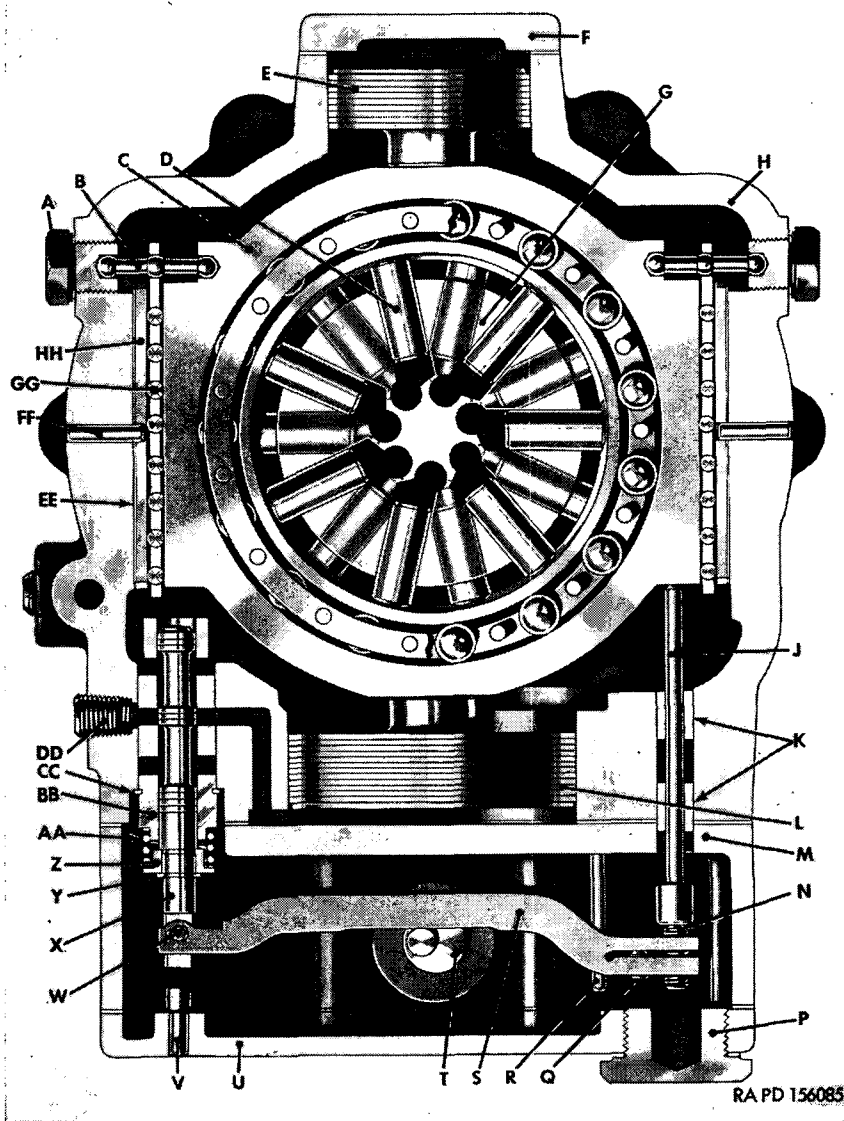
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Figure 46. Traversing control neutral lock cylinder—cross section.

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having a double beveled inner race and a hydraulic servo-motor dual piston control mechanism (figs. 47 and 48). The traversing-pump shaft rotates in a front ball bearing mounted in the gear pump housing and a rear ball bearing mounted in the pump case. It is driven by the electric drive motor gear through an idler gear mounted on an idler gear stub shaft in the gear pump housing and a drive gear mounted on the traversing-pump shaft. Drilled holes in the idler-gear shaft and gear-pump housing, centrifugal force plus the oil pressure, keeps the beveled surfaces of the 14 rolling pistons against the inner race of the slide block assembly at all times. The inner race of the slide block assembly rotates with the traversing pump shaft through contact of the 14 rolling pistons. The slide block assembly moves on two sets of caged rollers between the ground surfaces on the slide block assembly and the slide-block roller plates in the pump case, and is actuated accurately to the left of the traversing-pump-shaft axis by a small control piston and to the right by a large control piston. Guide pins, extending through the roller cages and pivoted in the slide block assembly and guide pin caps assure movement of the cages and rollers. Increasing the eccentricity of the slide block assembly increases the stroke of the rolling pistons and the volume of oil discharged. Reversing the eccentricity of the slide block assembly reverses the direction of oil flow.

- (4) *Pump flat valve* (figs. 48 and 50). Four springs hold the four back-up pistons in the traversing pump end head against the traversing pump flat valve. Two equalizer pistons in the traversing pump flat valve balance the hydraulic force which tends to separate traversing pump flat valve from the ported end of the traversing pump shaft. The valve locating pins pressed into the pump end head and a retaining ring hold the traversing pump flat valve in place for convenience in assembly.
- (5) *Gear pump* (fig. 48). Keyed to the traversing pump shaft is a gear pump drive gear which meshes with a gear pump driven gear mounted on a gear pump driven gear bearing and a gear pump driven gear shaft mounted in the gear pump housing and gear pump cover. Both gears are closely fitted in the gear pump housing and held in place with a gear pump cover. On the traversing pump shaft and behind the gear pump driven gear is an oil seal ring. The gear pump



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Figure 47. Hydraulic turret-traversing pump (Oilgear Model AT-411) front-elevation cross section.

suction port 8 in the gear pump housing is connected to port 13 in the oil reservoir through a connector, tube and fittings. The gear pump discharge is out port 9 in the gear pump housing, through a connector, hydraulic filter and hydraulic lines to the gear pump relief valve port 12 in the oil reservoir

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Figure 47—Continued

A—CAP, GUIDE PIN—7352033
B—PIN, GUIDE—A245613
C—BLOCK, SLIDE, ASSY—7353139
D—PISTON, ROLLING—7352059
E—PISTON, CONTROL, SMALL—7352035
F—COVER, CONTROL, SMALL—7352037
G—SHAFT, PUMP—7353158
H—CASE, PUMP—7353167
J—PIN, FOLLOW-UP, ASSY—7352032
K—BUSHING, FOLLOW-UP PIN—7737555
L—PISTON, CONTROL, LARGE—7352034
M—CASE, CONTROL, LOWER—7353172
N—SCREW, SET, SOCKET-HEAD, $\frac{1}{4}$ -28NF-2 x $\frac{1}{4}$ —
P—CAP, FOLLOW-UP PIN SPRING—7353121
Q—SCREW, SET, SOCKET-HEAD, NO. 10-32NF-2 x $\frac{1}{4}$ —222374
R—PIN, GUIDE, CONTROL LEVER—7353128
S—LEVER, CONTROL—7353142
T—SHAFT, ECCENTRIC—7353141
U—COVER, CONTROL LEVER—7353103
V—PIN, PLUNGER STOP—7353102
W—PIN, SHOULDER, CONTROL LEVER—A245578
X—PLUNGER, PILOT VALVE—7352029
Y—RING, RETN, SPRING GUIDE—583029
Z—GUIDE, PILOT VALVE SPRING—7352027
AA—SPRING, PILOT VALVE PLUNGER—7737504
BB—BUSHING, PILOT VALVE—7352028
CC—RING, RETN, EXTERNAL (SPIRALOX, RS-75)
DD—PLUG, PIPE, $\frac{1}{8}$ —444687
EE—SHIM, SLIDE BLOCK PLATE-TO-CASE—7002666
FF—PIN, DOWEL—A244981
GG—ROLLER, W/CAGE, ASSY—A245567
HH—PLATE, SLIDE BLOCK ROLLER—A245612

and the traversing pump case. A separate hydraulic line connects the traversing and elevating pump cases.

- (6) *Pump end head* (figs. 48, 49, and 50). Two spring-loaded, plunger-type gear pump supercharge check valves, each consisting of a disk, spring, gasket, and cap, are built into two sides of the traversing pump end head (fig. 49). Two spring-loaded, ball-type accumulator system supercharge check valves, each consisting of a ball, guide, spring, gasket, and cap, are built into end of the traversing pump end head (fig. 48). An accumulator system ball-type relief valve consisting of a ball, guide, spring, shim, and cap is built into one side of the traversing pump end head (fig. 50). Two pipe taps, stamped ports 3 and 4, receive two connectors screwed in ports 3 and 4 on the oil reservoir and the pipe tap stamped 5 receives a connector screwed in port 5 on the oil reservoir.



Figure 48. Hydraulic turret-traversing pump (Oilgear Model AT-411) side-elevation cross section.

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Figure 48—Continued

A—CAP, GUIDE PIN—7352033
B—BLOCK, SLIDE, ASSY—7353139
C—CASE, PUMP—7353167
D—BEARING, BALL, REAR—710059
E—RING, RETN, FLAT VALVE—7352003
F—VALVE, FLAT, PUMP—7353153
G—GASKET, O RING, BACK-UP PISTON—7352009
H—SPRING, BACK-UP PISTON—A245550
J—PLUG, PIPE, $\frac{1}{4}$ —444691
K—GUIDE, CHECK VALVE BALL—7352041
L—GASKET, O RING, CHECK VALVE CAP—7352002
M—CAP, CHECK VALVE—7352043
N—SPRING, BALL CHECK VALVE—A195973
P—BALL, $\frac{1}{2}$ —104922
Q—HEAD, END, PUMP—7353159
R—PISTON, BACK-UP—7352061
S—SHAFT, PUMP—7353158
T—ROLLER, W/CAGE, ASSY—A245567
U—PLATE, SLIDE BLOCK ROLLER—A245612
V—PIN, DOWEL—A244981
W—SHIM, SLIDE BLOCK PLATE-TO-CASE—7002666
X—SCREW, CAP, SOCKET-HEAD, $\frac{1}{16}$ -18NC-2 x $\frac{1}{8}$ —451987
Y—PISTON, ROLLING—7352059
Z—GEAR, IDLER, PUMP—7352019
AA—RING, RETN, IDLER-GEAR-TO-BEARING—583015
BB—BEARING, BALL, IDLER GEAR—701150
CC—RING, RETN, IDLER-GEAR-SHAFT-TO-BEARING—583378
DD—SHAFT, IDLER GEAR—7352063
EE—RING, RETN, FRONT-BEARING-TO-HOUSING—583327
FF—BEARING, BALL, FRONT—700386
GG—RING, RETN, FRONT-BEARING-TO-SHAFT—583383
HH—RING, RETN, GEAR-TO-SHAFT—583040
JJ—GEAR, DRIVE, PUMP—7352020
KK—KEY, WOODRUFF, $\frac{1}{32}$ x $\frac{1}{8}$ —106750
LL—KEY, WOODRUFF, $\frac{1}{32}$ x $\frac{1}{2}$ —103904
MM—GEAR, DRIVE, GEAR PUMP—7353097
NN—SHAFT, GEAR PUMP DRIVEN GEAR—7353096
PP—BEARING, GEAR PUMP DRIVEN GEAR—A245577
QQ—GEAR, DRIVEN, GEAR PUMP—A245575
RR—COVER, GEAR PUMP—7353093
SS—HOUSING, GEAR PUMP—7353168
TT—GASKET, HOUSING-TO-CASE—7353147
UU—RING, OIL SEAL—7737593

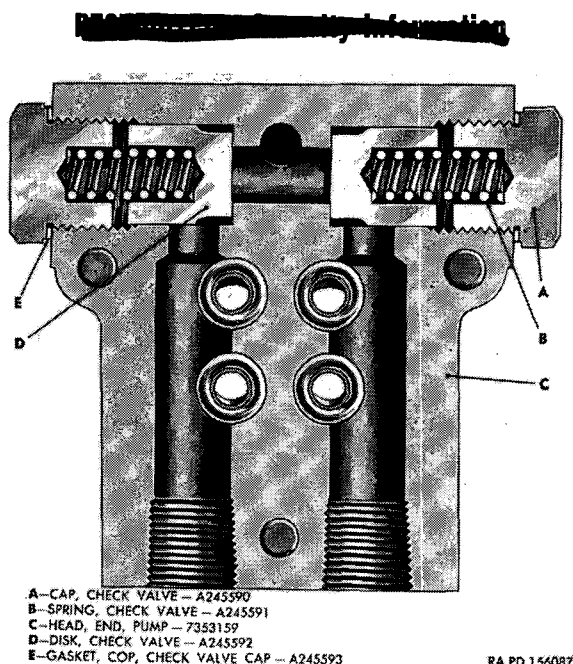


Figure 49. Check valves in traversing pump end head—cross section.

- (7) *Oil passages.* Passages in the gear pump housing, hydraulic filter, hydraulic lines, traversing pump case, and traversing pump end head connect the gear pump discharge to end head check valves, pilot valve bushing and large and small control pistons. Drilled passages in the traversing pump end head connect the radial piston pump discharge to the end head check valves and ports 3 and 4. Drilled passages in the traversing pump end head connect the accumulator system to check valves and relief valve through port 5.

e. Two-way, Variable-Delivery Elevating Pump (Oilgear Model ATT—411) (figs. 38 and 39).

- (1) *Upper control mechanism* (figs. 42, 43, 51, and 52). The upper control mechanism consists of a fractional horsepower direct current, variable speed, reversible electric signal motor assembly (Minneapolis-Honeywell Model G-2059A1) with four connecting white leads (fig. 42). The signal motor assembly is fastened to the upper control case. Connecting leads are soldered to a flanged type electrical connector receptacle. A signal motor shaft gear splined and locked to the signal motor shaft meshes with a worm shaft gear pressed on worm shaft. A control worm pressed on worm shaft meshes with a differential input gear keyed to the differential shaft (fig. 43). The differential shaft is mounted on two anti-

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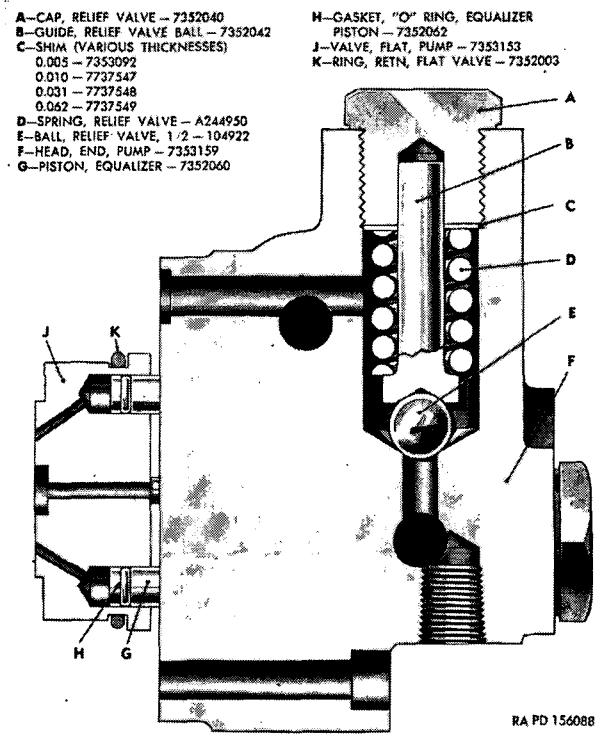


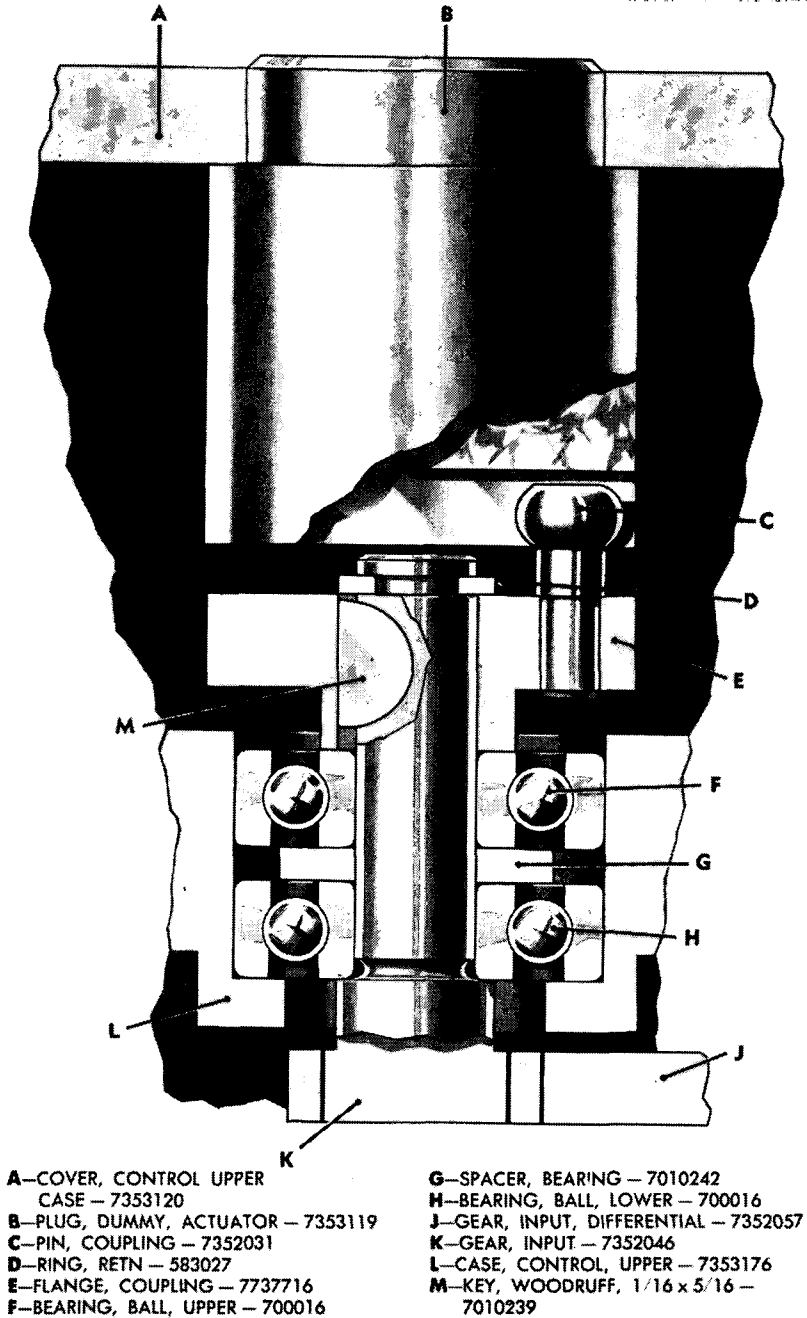
Figure 50. Accumulator system relief valve in traversing pump end head—cross section.

friction upper and lower ball bearings. The lower sun gear, keyed to the differential shaft, and resting on the lower sun gear bearing, meshes with the two lower planetary gears mounted on hardened and ground dowel pins pressed into the differential output gear carrier. The two upper planetary gears mounted on hardened and ground dowel pins pressed into the differential output gear carrier, mesh with the upper sun gear which is free to rotate on the differential shaft and the upper sun gear ball bearing. Two planetary gears on each side of the upper and lower sun gears mesh with each other. A bearing retainer for the lower sun gear ball bearing is fastened to the differential output gear carrier with four socket head screws and lock washers. The output elevating differential gear, keyed to the differential output gear carrier, meshes with the elevating clutch gear which is part of the lower elevating control mechanism. An input feedback differential gear, keyed to the upper sun gear, meshes with the input feedback gear of the superelevating differential. This

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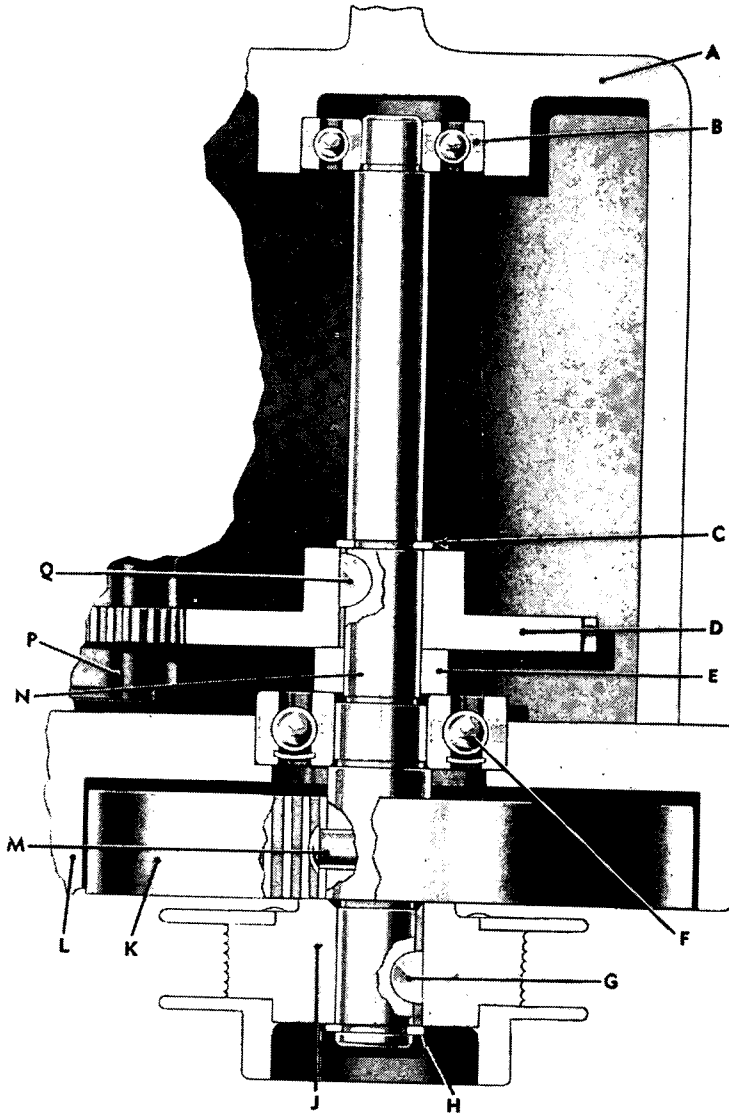
input feedback gear is keyed to the upper sun gear which is free to rotate on the superelevating differential shaft and the upper sun gear ball bearing. The upper sun gear meshes with the two upper planetary gears mounted on hardened and ground dowel pins pressed into the differential output gear carrier. Two planetary gears on each side of the upper and lower sun gears mesh with each other. Two lower planetary gears mesh with the lower sun gear which is keyed to the stationary superelevating differential shaft. An actuator dummy plug, in the elevating control upper case cover, holds the superelevating coupling pin, superelevating coupling flange, superelevating input gear, superelevating differential input gear and superelevating differential shaft stationary (fig. 51). The superelevating input gear is mounted on two upper and lower antifriction ball bearings. The superelevating differential shaft is mounted on two upper and lower antifriction ball bearings. The output elevating differential gear, keyed to the differential output gear carrier, meshes with the feedback shaft gear which is keyed to the elevating feedback shaft and mounted on two upper and lower antifriction ball bearings in the upper and lower elevating control cases. A dowel pin pressed into the upper control case which incloses the above mechanism, limits the angular movement of the clutch limit plate. When the power pack is installed in the tank, the elevating control upper case cover and the actuator dummy plug is removed and a superelevating device is mounted on the elevating control upper case and engages the superelevating coupling pin.

- (2) *Lower control mechanism* (figs. 45, 47, and 53). A clutch limit plate is keyed to elevating control eccentric shaft and confined on the top with a plate retaining ring (fig. 45). A slip clutch spring confined between a fixed clutch spring guide and a floating clutch spring guide, an upper ball bearing and elevating clutch gear, loads the elevating clutch gear onto the clutch limit plate and holds the elevating control eccentric shaft and the lower ball bearing in place. A spring-loaded neutral lock plunger is closely fitted to the neutral lock cylinder and mounted directly below the eccentric stub on the elevating control eccentric shaft (fig. 53). The pilot valve plunger spring between the pilot valve bushing and the pilot valve spring guide remove the play between the pilot valve plunger and the control lever, holds the control lever tight against the eccentric stub on the elevating control eccen-



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Figure 51. Superelevating input gear and dummy plug—cross section.



- | | |
|--|--|
| A—CASE, CONTROL, UPPER — 7353176 | H—RING, RETN, PULLEY — 583031 |
| B—BEARING, BALL, UPPER — 700019 | J—PULLEY, ASSY — 7737502 |
| C—RING, RETN, FEED-BACK SHAFT GEAR — 583031 | K—SPRING, FEED-BACK SHAFT — 7353094 |
| D—GEAR, FEED-BACK SHAFT — 7353114 | L—CASE, CONTROL, LOWER — 7353171 |
| E—SPACER, FEED-BACK SHAFT GEAR — 7010232 | M—PIN, ANCHOR, SPRING — 7737500 |
| F—BEARING, BALL, LOWER — 710038 | N—SHAFT, FEED-BACK — 7353146 |
| G—KEY, WOODRUFF, 1 16 x 5 16, PULLEY — 7010239 | P—KEY, WOODRUFF, 1/16 x 5/16, FEED-BACK SHAFT GEAR — 7010239 |
| | Q—DIFFERENTIAL, ASSY — 7737582 |

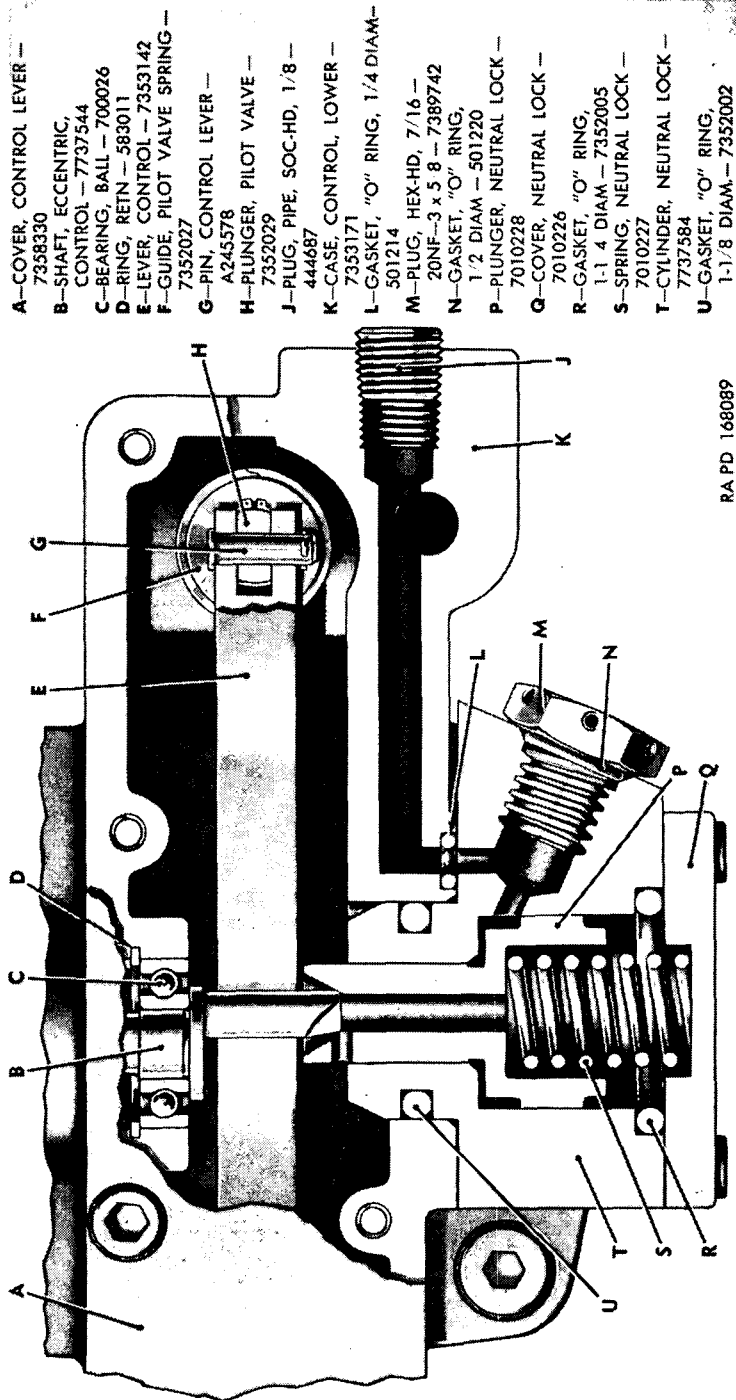
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Figure 52. Elevating feedback shaft, pulley, spring and gear—cross section.

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tric shaft and the socket head set screw on one end of the control lever tight against the follow-up pin assembly (fig. 47). Two guide pins pressed into the lower elevating control case, guide the control lever. Pilot valve plunger is closely fitted to the pilot valve bushing which is inserted into the elevating pump case and held in place by an external retaining ring. A spring anchor pin pressed into the input feedback shaft holds one end of feedback shaft spring while the loop on the other end of the feedback shaft spring is held in a slot against lower elevating control case. A cable pulley assembly is keyed to the input feedback shaft and held in place with a pulley retaining ring.

- (3) *Radial piston pump* (figs. 47 and 54). The two-way variable-delivery, hydraulic elevating pump consists essentially of a stationary, balanced, elevating pump flat valve; a ported elevating pump shaft with 14 radial cylinders having closely fitted rolling pistons; a slide block assembly with a piston reaction ball bearing having a double beveled inner race and a hydraulic servo-motor dual piston control mechanism (figs. 47 and 54). The elevating pump shaft rotates on a front ball bearing mounted in the dither pump housing and a rear ball bearing mounted in the pump case. It is driven by the electric motor drive gear through the elevating pump drive gear mounted on the elevating pump shaft. Centrifugal force, plus the oil pressure, keeps the beveled surfaces of the 14 rolling pistons against the inner race of the slide block assembly at all times. The inner race of the slide-block assembly rotates with the elevating pump shaft through contact of the 14 rolling pistons. The slide block assembly moves on two sets of caged rollers between the ground surfaces on the slide block assembly and the slide block roller plates in the pump case, and is actuated accurately to the left of the elevating pump shaft axis by a small control piston and to the right by a large control piston. Guide pins, extending through the roller cages and pivoted in the slide block assembly and guide pin caps assure movement of the cages and rollers. Increasing the eccentricity of the slide block assembly increases the stroke of the rolling pistons and the volume of oil discharged. Reversing the eccentricity of slide block assembly reverses the direction of oil flow.
- (4) *Pump flat valve* (figs. 54 and 56). Four springs hold the four back-up pistons in the elevating pump end head against the elevating pump flat valve. Two equalizer pistons in the



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Figure 53. Elevating control neutral lock cylinder—cross section.

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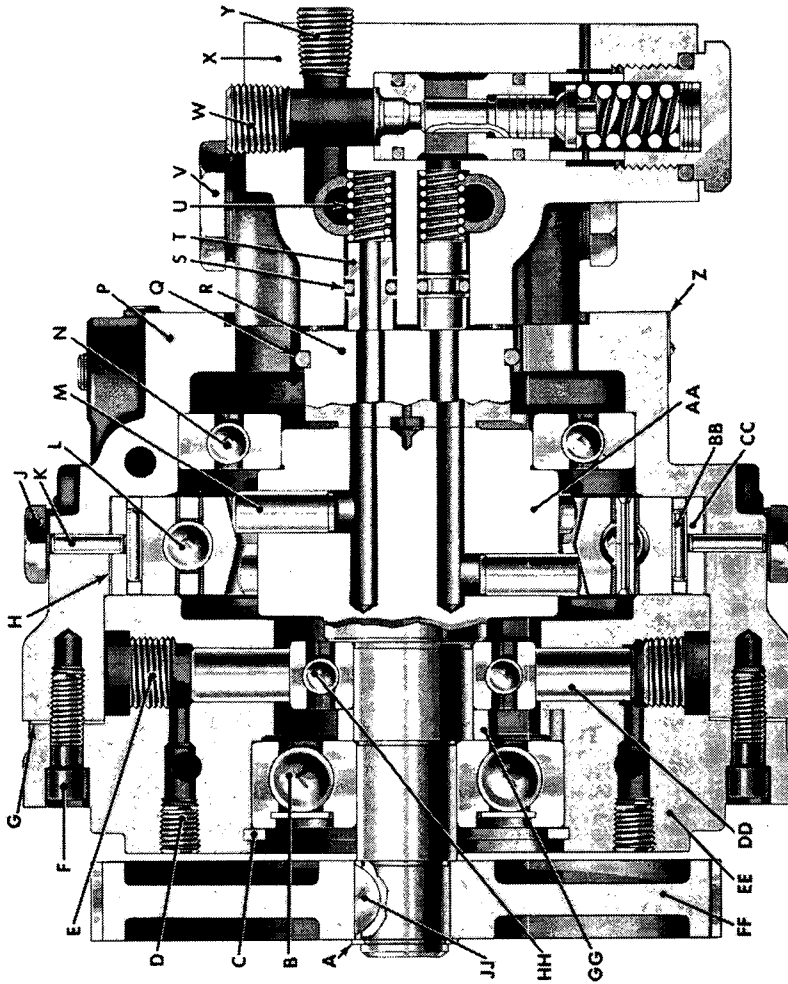
elevating pump flat valve balance the hydraulic force which tends to separate the elevating pump flat valve from the ported end of the elevating pump shaft. The valve locating pins pressed into the elevating pump end head and a retaining ring hold the elevating pump flat valve in place for convenience in assembly.

- (5) *Dither pump* (figs. 54 and 55). The dither pump consists essentially of four dither pump pistons closely fitted to four radial cylinders 90° apart in the dither pump housing which is flanged to the elevating pump case (fig. 55). The inner race of the dither pump ball bearing is pressed onto an eccentric integral with the elevating pump shaft while the outer race contacts the dither pump pistons (fig. 54). Each piston is connected to ports 6, 7, 10, and 11, respectively, through drilled passages in the dither pump housing.
- (6) *Pump end head* (figs. 54 and 56). Two spring-loaded, plunger type gear pump supercharge check valves, each consisting of a disk, spring, gasket, and cap, are built into two sides of the elevating pump end head (fig. 49). The elevating radial piston system two-way, reverse flow type relief valve, consisting essentially of a bushing, plunger, spring, spring guide, shims, and "O" ring gaskets, is built into the side of the elevating pump end head. Two pipe taps, stamped ports 1 and 2, receive two connectors screwed in ports 1 and 2 on the oil reservoir.
- (7) *Oil passages*. Passages in the hydraulic filter, hydraulic lines, elevating pump case, and end head connect the gear pump discharge from traversing pump gear pump to the end head check valves, pilot valve bushing, large and small control pistons and neutral lock cylinder. Drilled passages in the elevating pump end head connect the radial piston pump discharge to the end head check valves and ports 1 and 2. Drilled passages in the dither pump housing connect ports 6, 7, 10, and 11 to each dither pump piston, respectively.

f. Electric Signal Motor (Minneapolis-Honeywell Model G2059A1). Refer to paragraph 22.

g. Oil Reservoir.

- (1) *Reservoir* (figs. 38 and 39). The welded steel rectangular oil reservoir consists essentially of a reservoir, cover, breather cap, bayonet-type oil level gauge, oil filler strainer, low-pressure gear pump relief valve, five connectors with "O" ring gaskets, five pipe tap thread drain connections, one pipe tap thread suction connection and three mounting pads. The



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Figure 54. Hydraulic gun-elevating pump (Oilgear Model ATT-41) side-elevation cross section.

Figure 54—Continued.

A—RING, RETN, GEAR—580340	S—GASKET, "O" RING, BACK-UP PIS- TON—7352009
B—BEARING, BALL, FRONT—700871	T—PISTON, BACK-UP—7352061
C—RING, RETN, BEARING—583337	U—SPRING, BACK-UP PISTON—A245550
D—PLUG, PIPE, $\frac{1}{8}$ —444687	V—CAP, CHECK VALVE—A245590
E—PLUG, PISTON HOLE, DITHER PUMP—7737501	W—PLUG, PIPE, $\frac{3}{8}$ —444697
F—SCREW, CAP, SOCKET-HEAD, $\frac{5}{16}$ — 18NC-2 x $\frac{7}{8}$ —451987	X—HEAD, END, PUMP—7353154
G—GASKET, HOUSING-TO-CASE— 7353147	Y—PLUG, PIPE, $\frac{1}{4}$ —444691
H—SHIM, SLIDE BLOCK PLATE-TO- CASE—7002666	Z—PLATE, NAME—B197531
J—CAP, GUIDE PIN—7352033	AA—SHAFT, PUMP—7353157
K—PIN, DOWEL—A244981	BB—ROLLER, W/CAGE, ASSY—A245567
L—BLOCK, SLIDE, ASSY—7353139	CC—PLATE, SLIDE BLOCK ROLLER— A245612
M—PISTON, ROLLING—7352059	DD—PISTON, DITHER PUMP—7353101
N—BEARING, BALL, REAR—710059	EE—HOUSING, DITHER PUMP—7353169
P—CASE, PUMP—7353167	FF—GEAR, DRIVE, PUMP—7353140
Q—RING, RETN, FLAT VALVE—7352003	GG—SPACER, BEARING—7352036
R—VALVE, FLAT, PUMP—7353156	HH—BEARING, BALL, DITHER PUMP— 700079
	JJ—KEY, WOODRUFF, $\frac{5}{16}$ x $\frac{3}{8}$ —106750

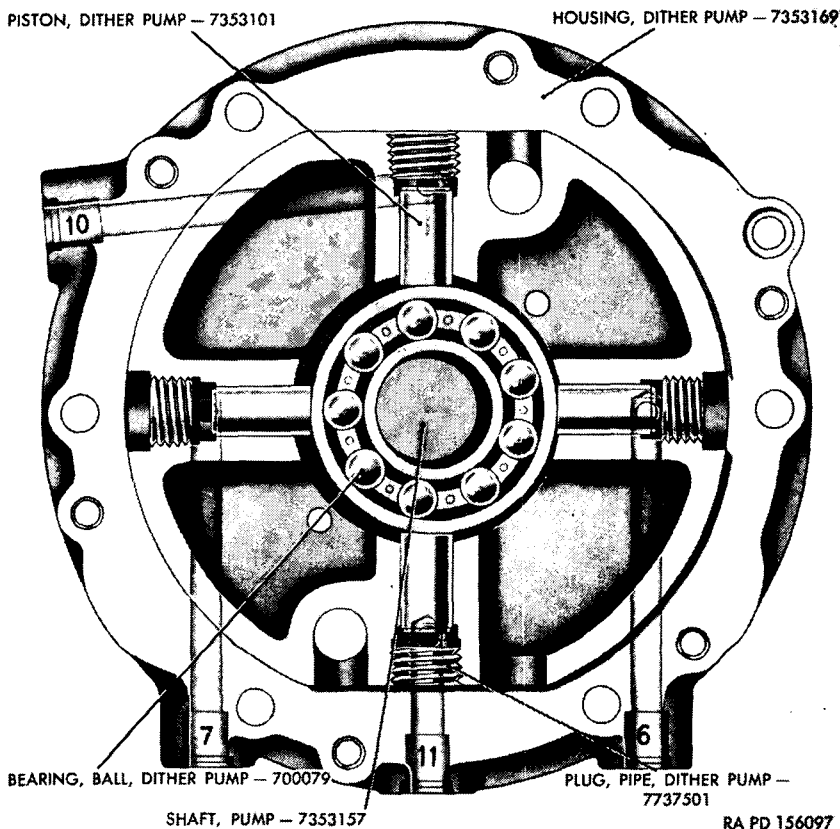


Figure 55. Dither pump—front-elevation cross section.

oil reservoir cover provides mounting for the traversing and the elevating pumps. Connectors with "O" ring gaskets screw into ports 1, 2, 3, 4, and 5 of the traversing and elevating pump end heads. Tube fittings are screwed into ports 12 and 13.

- (2) *Gear pump relief valve* (fig. 57). A low-pressure, reverse flow type relief valve consisting essentially of a bushing, plunger, spring, spring guides, shims, and "O" ring gaskets is built into the oil reservoir. The gear pump discharge is directed to a baffled chamber in the oil reservoir. A drilled passage connects the spring chamber to the oil in the reservoir.

h. Hydraulic filter (fig. 58). The hydraulic filter consists essentially of a head assembly, an element assembly and a case. Built into the cast aluminum head are two piston-type relief valves each consisting of a piston, spring, guide, gasket and cover screw. The filtering

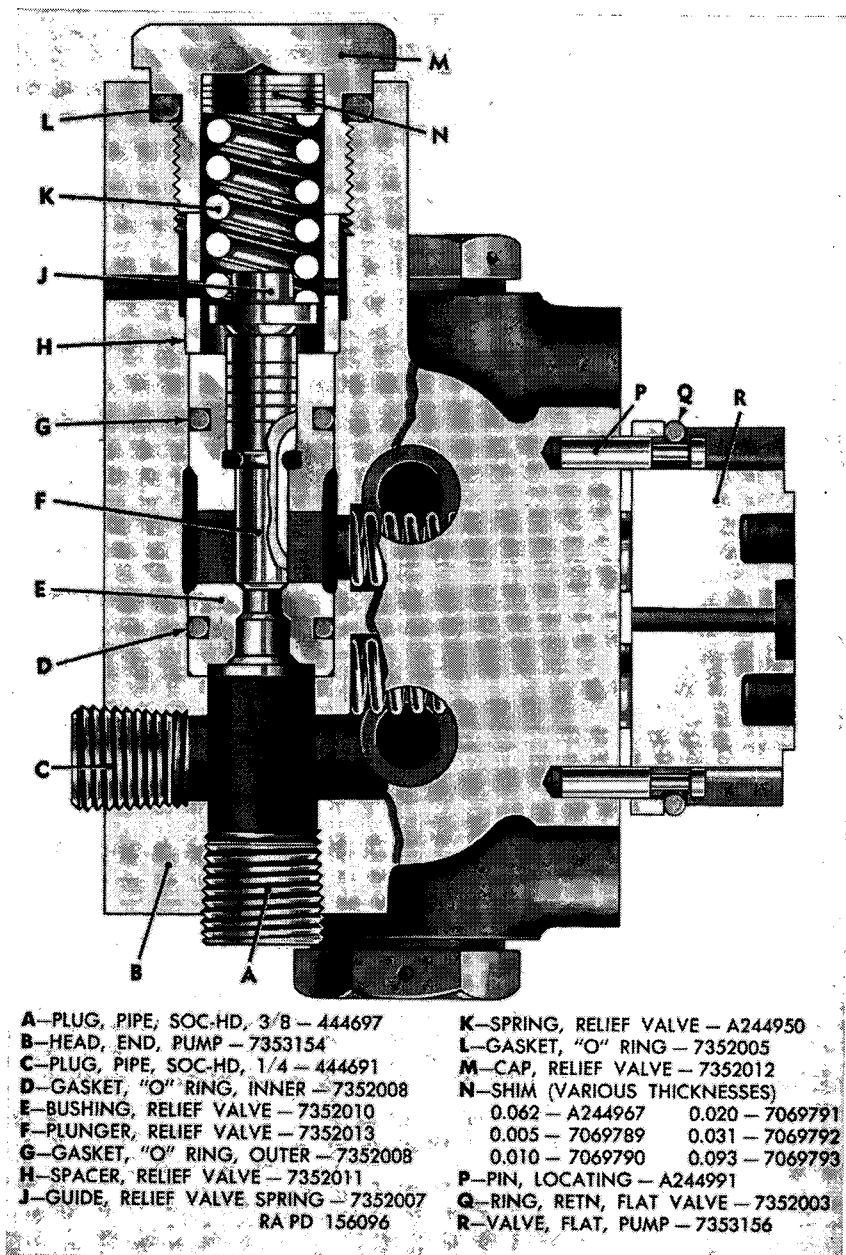


Figure 56. Relief valve in elevating pump end head—cross section.

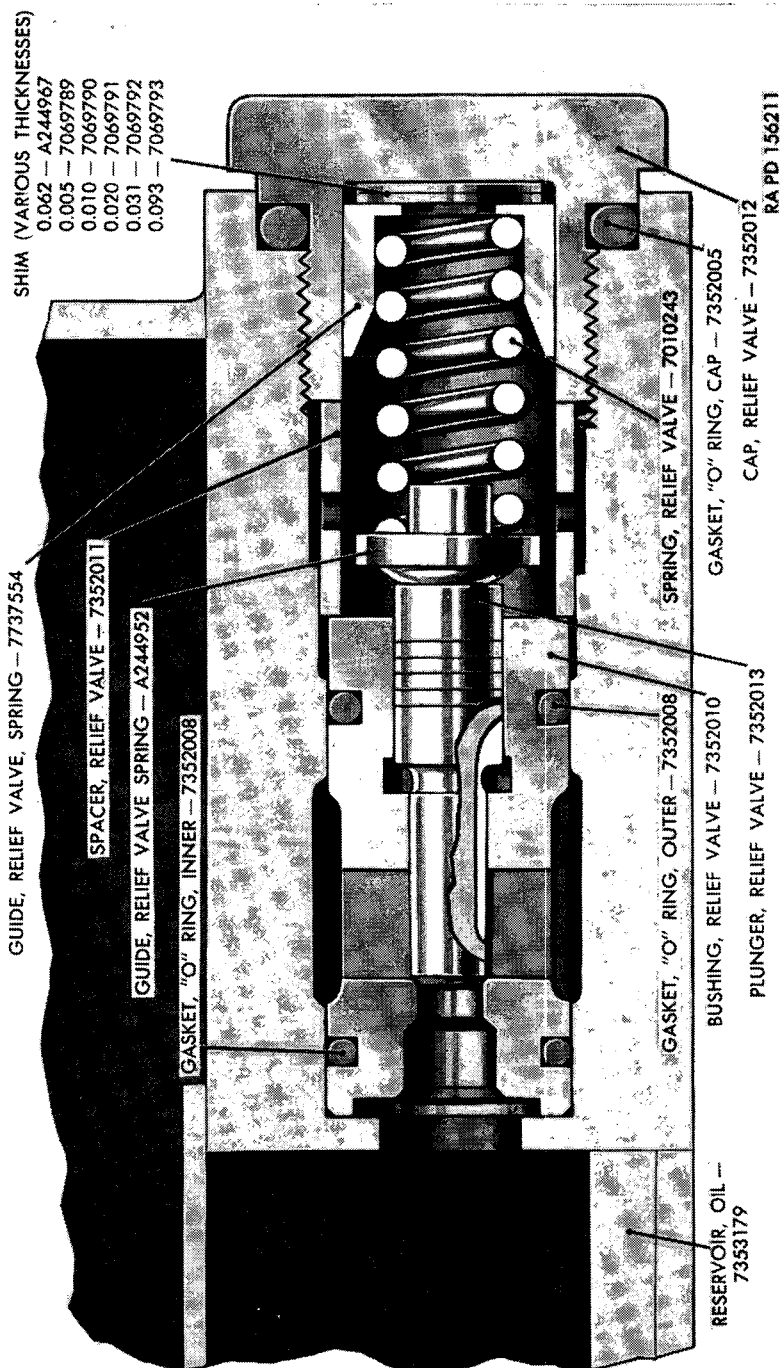
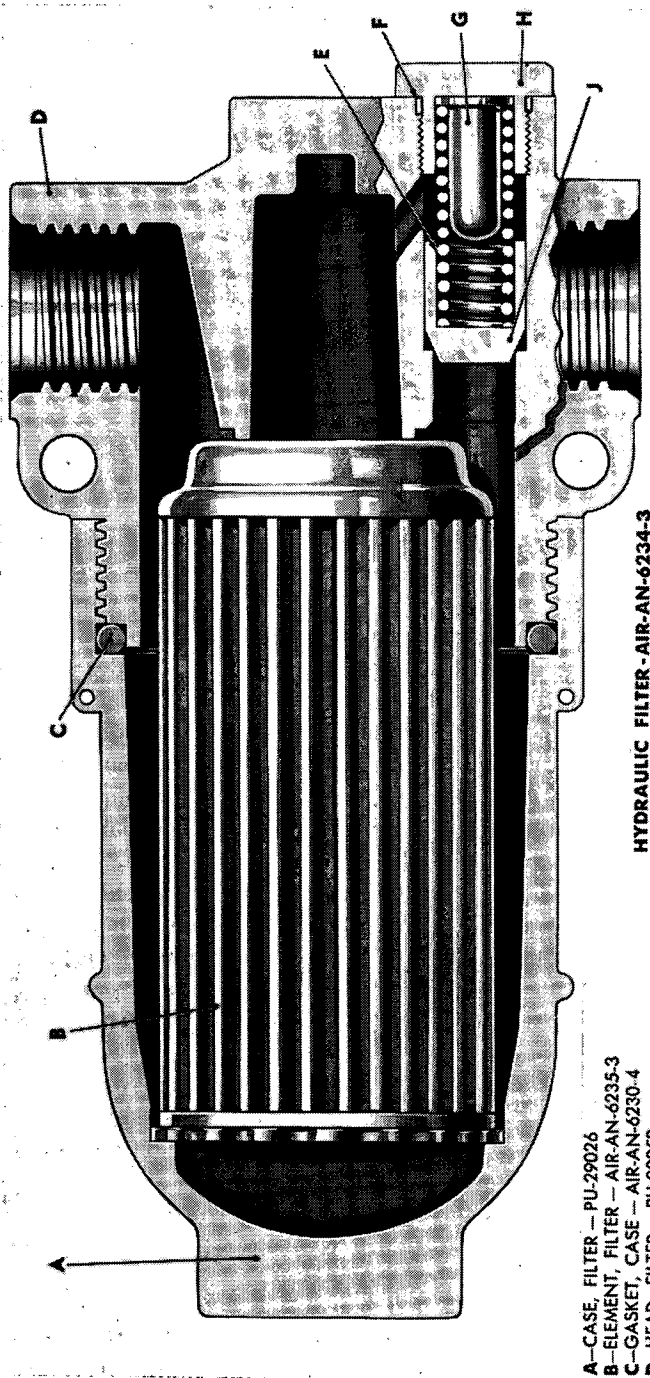


Figure 57. Gear pump relief valve in oil reservoir—cross section.

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Figure 58. Hydraulic filter—cross section.

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element assembly is a treated cellulose formed in vertical convolutions bonded to an outlet sealing bushing and a base sealing star-shaped washer. A spring in the element core reinforces the element. A gasket seals the element to the head. The cast aluminum case screws into the head and the joint is sealed with a gasket. Lock wires secure the relief valve cover screws and filter case to the head assembly.

i. Lines and Fittings.

- (1) *Lines.* Annealed steel lines, cut to length, bent to suit power pack, and fitted with sleeves and nuts are used to connect fittings in traversing and elevating pump cases, in gear pump suction ports 8 and 13 and fittings in gear pump discharge from the hydraulic filter to port 12 and traversing pump case.
- (2) *Fittings.* Flareless, locking shoulder joint elbows and tees are furnished as integral parts of the power pack.

29. Principle of Operation

a. General. A constant-speed, electric drive motor drives a two-way, variable-delivery hydraulic turret-traversing pump and a two-way, variable delivery hydraulic gun-elevating pump. Controlled fluid power, generated by the traversing pump in response to the gunner's or the commander's power traversing control handles and the resistance encountered by the turret, flows to and from the constant-displacement hydraulic traversing motor for power traversing the turret quickly and accurately. Controlled fluid power, generated by the elevating pump in response to the gunner's or the commander's power elevating control handles and the resistance encountered by the gun, flows to and from a nondifferential double-acting elevating cylinder for power elevating and depressing the gun quickly and accurately. The desired power, up to maximum, from either or both pumps can be selected at will by the gunner or the commander. Practically all static friction in the traversing mechanism and part of the traversing pump control is eliminated automatically by the built-in dither pump.

b. Electric Drive Motor (figs. 38 and 39). The electric drive motor is a compound-wound 5-hp 24-volt dc motor. This design permits momentary heavy loads by the hydraulic pumps in response to signals from full actuation of the gunner's or commander's controls. The motor maintains a satisfactory torque at rated speed to permit instant response to minor loads imposed by the hydraulic pumps in response to minor traverse or elevation signals from the gunner's or commander's control.

c. Drive Gear Case (figs. 38 and 39). Inclosure for the electric motor, drive gear, traversing pump and elevating pump drive gears

and flanged mounting for the electric motor, traversing pump and elevating pump are provided by the drive gear case.

d. *Two-way, Variable-Delivery Traversing Pump (Oilgear Model AT-411)* (figs. 38 and 39).

(1) *Upper and lower control mechanism* (fig. 59).

Note. The key letters in this subparagraph refer to figure 59.

A fractional horsepower, direct current, variable speed, reversible electric signal motor (N) (fig. 42), controlled by the gunner's power traversing control handle (fig. 24) or the crew commander's control handle (fig. 20), drives the traversing pump upper control differential in either direction to actuate the traversing eccentric control shaft and the hydraulic servo-motor piston control and provide the desired turret traversing speed and direction of turret rotation. It drives the signal motor shaft gear (D), worm shaft gear (C) (fig. 42), control worm (A), differential input gear (B) (fig. 43), lower sun gear (J), lower planetary gear (H) and (HH), upper planetary gears (G) and (GG), upper sun gear (F) and input feedback differential gear (E). When input feedback shaft (NN) (fig. 44), upper input feedback gear (MM), lower input feedback gear (JJ), input feedback differential gear (E) (fig. 43) and upper sun gear (F) are stationary or rotating slower or faster than the speed demanded by the lower sun gear (J), the lower planetary gears (H) and (HH) and the upper planetary gears (G) and (GG), rotate the output gear carrier (K) to turn output traversing differential gear (L), traversing clutch gear (DD) (fig. 45) and traversing eccentric control shaft (BB). Counterclockwise rotation of traversing eccentric control shaft (BB) (fig. 47) will move control lever (Y) and pilot valve plunger (S) inward to permit the gear pump oil to flow through the pilot valve bushing (R) to the large control piston (U) and move the slide block assembly (M) inward (to the right). As the slide block assembly (M) moves inward, the pilot valve plunger spring (T) forces one end of the control lever (Y) and the follow-up pin (AA) to follow the slide block assembly while it holds the control lever (Y) against the traversing eccentric control shaft (BB) and causes the pilot valve plunger (S) to move outward and shut off the flow of gear pump oil to the large control piston (U) and stop movement of the slide block assembly (M). As long as the electric signal motor (N) (fig. 42) continues to drive the lower sun gear (J) (fig. 43) at a fixed speed

and the input feedback shaft (NN) (fig. 44), with the upper input feedback gear (MM) and the lower input feedback gear (JJ), continues to rotate at the selected speed, the slide block assembly (M) (fig. 47) will remain at the position selected. When the speed of the electric signal motor (N) (fig. 42) is increased in the same direction the output gear carrier (K) (fig. 43), output traversing differential gear (L), traversing clutch gear (DD) (fig. 45) and traversing eccentric control shaft (BB) will turn further in a counterclockwise direction and cause the slide block assembly (M) to move inward (to the right) further. When the electric signal motor (N) (fig. 42) and the lower sun gear (J) (fig. 43) are stopped, the upper planetary gears (G) and (GG) and the lower planetary gears (H) and (HH) will cause the output gear carrier (K), the output traversing differential gear (L) and the traversing clutch gear (DD) (fig. 45) to rotate the traversing eccentric control shaft (BB) clockwise and move the control lever (Y) (fig. 47) and the pilot valve plunger (S) outward. Oil behind the large control piston (U) is then free to flow through the pilot valve bushing (R) to the oil reservoir as gear pump oil moves the small control piston (P) and the slide block assembly (M) outward (to the left). As the slide block assembly (M) moves outward, the follow-up pin (AA) forces one end of the control lever (Y) outward and the opposite end inward as it pivots on traversing eccentric control shaft (BB) fulcrum. As the pilot valve plunger (S) moves inward it shuts off the oil flow from the large control piston (U) and stops the slide block assembly (M) in the neutral position. When the rotation of the electric signal motor (N) (fig. 42) is reversed, the lower sun gear (J) (fig. 43) drives the upper planetary gears (G) and (GG), the lower planetary gears (H) and (HH), output gear carrier (K), traversing differential output gear (L) and the traversing clutch gear (DD) (fig. 45) to turn the eccentric control shaft (BB) (fig. 47) clockwise and move the control lever (Y) and the pilot valve plunger (S) outward (to the left). Oil behind the large control piston (U) is then free to flow through the pilot valve bushing (R) to the oil reservoir as gear pump oil moves the small control piston (P) and the slide block assembly (M) outward (to the left). As the slide block assembly (M) moves outward, the follow-up pin (AA) forces one end of the control lever (Y) outward and the opposite end inward

as it pivots on the traversing eccentric control shaft (BB) fulcrum. As the pilot valve plunger (S) moves inward it shuts off the oil flow from the large control piston (U) and stops movement of the slide block assembly (M). When the electric signal motor (N) (fig. 42) and the lower sun gear (J) (fig. 43) are stopped, the upper planetary gears (G) and (GG) and the lower planetary gears (H) and (HH) will cause the traversing differential output gear (L) and the traversing clutch gear (DD) (fig. 45) to rotate the eccentric control shaft (BB) (fig. 47) counterclockwise and move the control lever (Y) and the pilot valve plunger (S) inward. This permits the gear pump oil to flow through the pilot valve bushing (R) to the large control valve piston (U) and move the slide block assembly (M) inward (to the right). As the slide block assembly (M) moves inward, the pilot valve plunger spring (T) forces one end of the control lever (Y) and the follow-up pin (AA) to follow the slide block assembly (M) and cause the pilot valve plunger (S) to move outward and shut off the flow of gear pump oil to the large control piston (U) and stop movement of the slide block assembly (M). As long as the signal motor (N) (fig. 42) continues to drive the lower sun gear (J) (fig. 43) at a fixed speed and the input feedback shaft (NN), with upper input feedback gear (MM) and lower input feedback gear (JJ), continues to rotate at the selected speed, the slide block assembly (M) will remain at the position selected. The several control movements, such as the electric signal motor drive, the input feedback drive and the traversing eccentric control shaft angular rotation, have been described as occurring in sequence but actually they all move and stop substantially in synchronism. Turret rotation, reversal and stopping responds immediately to the demands of the electric signal motor and the traversing differential control. A feedback gear in turret meshes with turret ring gear to drive the auxiliary input feedback shaft (LL) (fig. 44) through shafts and universal joints. Clutch limit plate (EE) (fig. 45) and clutch limit plate pin (FF) limit the angular movement of traversing eccentric control shaft (BB) to the maximum slide block assembly (M) stroke. Clutch spring (CC) maintains a preset contact between the traversing clutch gear (DD) and the clutch limit plate (EE). Traversing clutch gear (DD) can slip on the clutch limit plate (EE) when sudden surges or reversals of control occur, when clutch limit

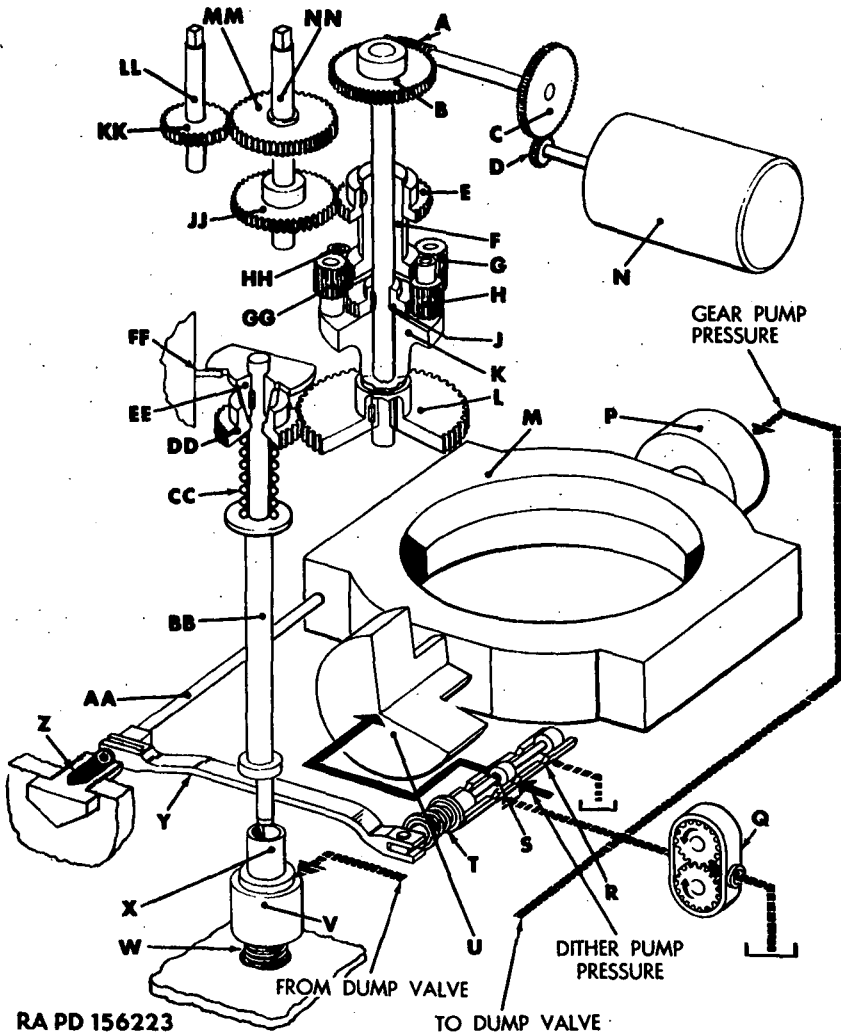


Figure 59. Turret-traversing hydraulic pump control—schematic isometric diagram.

- A—WORM, CONTROL—7352052
- B—GEAR, INPUT, DIFFERENTIAL—7352053
- C—GEAR, WORM SHAFT—7737551
- D—GEAR, SIGNAL MOTOR SHAFT—7369581
- E—GEAR, DIFFERENTIAL FEED-BACK INPUT—7353058
- F—GEAR, SUN, UPPER—7737579
- G—GEAR, PLANETARY, UPPER—7737572
- H—GEAR, PLANETARY, LOWER—7737572
- J—GEAR, SUN, LOWER—7737571
- K—CARRIER, OUTPUT GEAR—7737578
- L—GEAR, OUTPUT, TRAVERSING DIFFERENTIAL—7737515
- M—BLOCK, SLIDE, ASSY—7353139

Figure 59—Continued.

N—MOTOR, SIGNAL, ASSY—7383151
P—PISTON, CONTROL, SMALL—7352035
Q—GEAR, DRIVE, TRAVERSING PUMP—7353097
R—BUSHING, PILOT VALVE—7352028
S—PLUNGER, PILOT VALVE—7352029
T—SPRING, TRAVERSING PILOT VALVE PLUNGER—7737591
U—PISTON, CONTROL, LARGE—7352034
V—CYLINDER, NEUTRAL LOCK—7737584
W—SPRING, NEUTRAL LOCK—7010227
X—PLUNGER, NEUTRAL LOCK—7010228
Y—LEVER, CONTROL—7353142
Z—CAP, FOLLOW-UP PIN—7353121
AA—PIN, FOLLOW-UP—7352032
BB—SHAFT, ECCENTRIC, TRAVERSING CONTROL—7353141
CC—SPRING, SLIP CLUTCH—7353116
DD—GEAR, TRAVERSING CLUTCH—7010236
EE—PLATE, CLUTCH LIMIT—7352030
FF—PIN, DOWEL—A244981
GG—GEAR, PLANETARY, UPPER—7737572
HH—GEAR, PLANETARY, LOWER—7737572
JJ—GEAR, FEEDBACK SHAFT, LOWER—7352057
KK—GEAR, AUXILIARY FEEDBACK—7352022
LL—SHAFT, AUXILIARY FEEDBACK—7352054
MM—GEAR, FEEDBACK SHAFT, UPPER—7352056
NN—SHAFT, TRAVERSING FEEDBACK—7353148

plate reaches maximum angular rotation in either direction or when turret is traversed manually. Pilot valve spring (T) (fig. 47) eliminates play between the pilot valve plunger (S) and the control lever (Y) and keeps the control lever (Y) tight against the traversing eccentric control shaft (BB). An adjustment is provided between the control lever (Y) and the follow-up pin (AA) for selecting the neutral position. Pilot valve plunger (S) has a close negative seal fit with center port in the pilot valve bushing (R) to eliminate hunting of the hydraulic servo-motor piston control. One piston of the dither pump, built into the elevating pump, maintains an intermittent higher pressure at the center port of the pilot valve bushing to set up vibrations in certain movable parts in the traversing pump to provide instant response to the demands of the control. When the dump valve solenoid is energized or the power pack electric drive motor is shut off, and the gear pump pressure in the neutral lock cylinder (V) (fig. 50) drops, and the neutral lock plunger spring (W) raises the neutral lock plunger (X) to lock the traversing eccentric control shaft (BB) in the neutral posi-

tion. If the traversing eccentric control shaft (BB) and the slide block assembly (M) are on stroke, the cone shaped hole in the neutral lock plunger (X) forces the traversing eccentric control shaft (BB) to the neutral position and holds it there. This safety feature prevents the control from being on stroke and the turret from traversing unexpectedly when the power pack is started.

- (2) *Radial piston pump* (figs. 47 and 48). The turret traversing pump ported drive shaft, with 14 radial cylinders having closely fitted rolling pistons and 7 axial ports, is driven counterclockwise by an electric drive motor through an electric motor drive gear, traversing pump idler gear and traversing pump drive gear. Centrifugal force, combined with the pressure in the hydraulic traversing system, keeps the beveled surfaces of the rolling pistons against the inner race of the slide block ball bearing assembly. Through contact of the rolling pistons, the inner race of the slide block assembly rotates with the traversing pump shaft. The slide block assembly, which moves on the two slide block caged roller assemblies between ground surfaces on the slide block assembly and slide block roller plates in the pump case, is moved to the right of the traversing pump shaft axis by a large control piston and to the left of the traversing pump shaft axis by a small control piston. Increasing the eccentricity of the slide block assembly increases the stroke of the rolling pistons and the volume of oil discharged. Reversing the eccentricity of the slide block assembly reverses the direction of oil flow. When the center-line of the traversing pump and the slide block assembly do not coincide, the differences between the radii from the center of the traversing pump shaft to the points of contact of the rolling pistons with the inner race of the slide block assembly cause the rolling pistons to move faster or slower than their points of contact with the inner race of the slide block assembly. This difference in speed is adjusted by a low, partial rotation of each rolling piston in its traversing pump shaft bore—in one direction during the one-half revolution and in the opposite direction during the other half revolution. The rolling pistons thus rotate and reciprocate, simultaneously. Oil flows to and from the rolling pistons through machined passages in the traversing pump end head, back-up pistons, traversing pump flat valve and traversing pump shaft.

- [REDACTED]
- (3) *Hydraulic pump gear pump* (fig. 48). Gear pump gears suck oil from port 13 in the oil reservoir through the traversing pump port 8 and discharge the oil through port 9, a hydraulic filter, hydraulic lines and drilled passages to the pilot valve plunger for operating the large control piston and to the small control piston and through drilled passages and check valves in the end head to supercharge and lubricate the radial piston traversing pump and the radial piston traversing hydraulic motor system. Filtered gear pump oil is also delivered through hydraulic lines and drilled passages in the elevating pump case to the pilot valve plunger for operating the large control piston, the small control piston and the neutral lock plunger and through drilled passages and check valves in the elevating pump end head to supercharge and lubricate the radial piston elevating pump and the elevating cylinder. Gear pump oil is also delivered out port 9 and through the hydraulic filter and hydraulic lines to the traversing mechanism to actuate a spring loaded differential shifting piston and close the power traversing bypass valve. Gear pump oil is also delivered to the traversing pump neutral lock plunger through a solenoid-hydraulic operated dump valve. Excess gear pump oil flows in port 12 on the oil reservoir and is discharged past the gear pump relief (fig. 57) valve into the oil reservoir.
- (4) *Auxiliary relief valve and check valves* (figs. 48, 49, and 50). Built into the traversing pump end head is a ball type relief valve (fig. 50) which protects the hand-operated supercharge pump and accumulator system against overload, two spring loaded disc type check valves (fig. 49) which permit the gear pump to supercharge the traversing radial piston pump and the traversing hydraulic motor and two spring-loaded ball-type check valves (fig. 48) which permit the gear pump and traversing radial piston pump to supercharge the accumulator system when the power pack is started.
- (5) *Oil reservoir* (figs. 38 and 39). Oil from the rectangular reservoir is used as the fluid power medium in the hydraulic turret-traversing and hydraulic gun-elevating system. Both the hydraulic traversing pump and the hydraulic elevating pump are mounted on the oil reservoir cover. Internal slip and leakage from the traversing and elevating radial piston pumps, gear pump, dither pump, pilot valve plungers and control pistons and the oil discharged from the control and neutral lock cylinders drain from the pump cases directly

to the oil reservoir. A built-in, low pressure, reverse flow type relief valve limits the discharge pressure of the gear pump and directs the excess oil to the reservoir. Connectors with "O" ring gaskets enter side of the oil reservoir and end heads of both pumps to carry oil under pressure to and from external fittings and lines. An oil filter screen keeps the foreign material out of the oil reservoir. The oil level is measured on the bayonet type gage.

- (6) *Hydraulic filter* (fig. 58). Oil discharged by the gear pump to the inlet port of the hydraulic filter, flows around and through the micronic element to the center core and the outlet port. If the element becomes clogged, the oil will pass through the two relief valves.
- (7) *Neutral* (fig. 60). When the traversing eccentric control shaft is in neutral position "A," the center lines of the traversing pump ported drive shaft and slide block assembly coincide and no reciprocating motion is imparted to the rolling pistons. Thus, as the traversing pump shaft and pumping unit rotate, no oil is delivered by the traversing pump to the hydraulic traversing motor, so the turret remains stationary. Oil delivered by the gear pump actuates a spring loaded differential shifting piston to close the power traversing bypass valve and flows through a solenoid-hydraulic dump valve to operate the spring loaded neutral lock plunger. It also lubricates and supercharges the radial piston traversing pump and the radial piston traversing motor system. Two pistons of the four-piston hydraulic dither pump, built into the elevating pump, maintain an intermittent high pressure in the traversing system and set up vibrations in certain movable parts in the traversing hydraulic motor and traversing mechanism so that the hydraulic motor shaft can respond instantly to the demands of the control. One piston of the dither pump, built into the elevating pump, maintains an intermittent higher pressure at the center port of the pilot valve bushing to set up vibrations in certain movable parts in the traversing pump to provide instant response to the demands of the control.
- (8) *Clockwise traversing motor rotation* (fig. 61). When the electric signal control motor drives the differential in the upper control mechanism to rotate the traversing eccentric control shaft through the arc from position "A" to position "B" (fig. 61), the pilot valve plunger end of the control lever and the pilot valve plunger move to the left allowing oil behind the large control piston to flow out

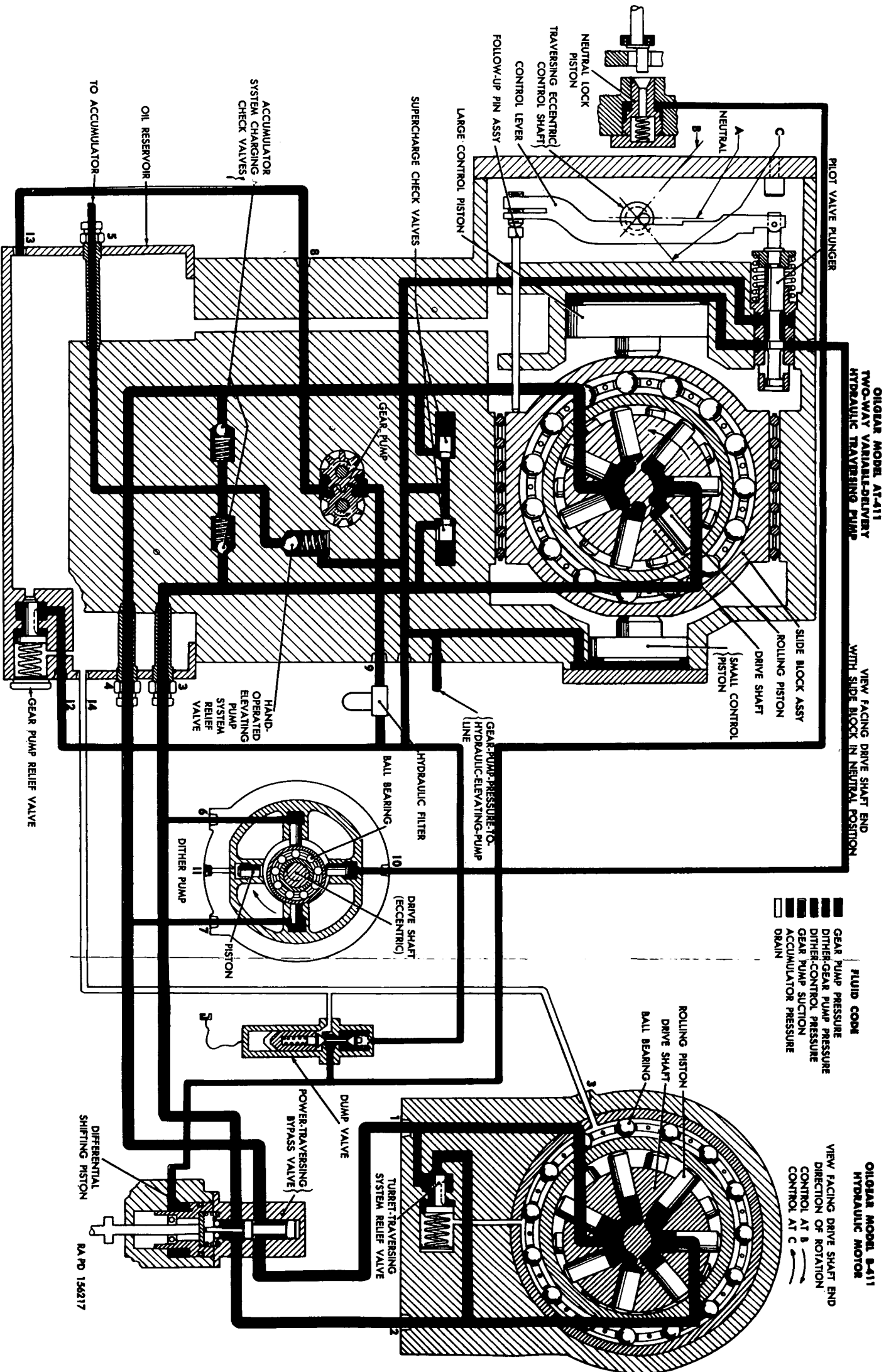
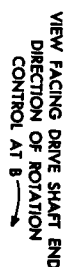


Figure 60. Hydraulic turret-traversing system oil circuit (neutral).



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of the pilot valve bushing to the oil reservoir as the gear pump oil moves the small control piston, slide block assembly and large control piston to the left. Reciprocating motion is so imparted to the rolling pistons that those passing through the arc of the lower crescent passage in the traversing pump flat valve deliver oil to that crescent passage, to two back-up pistons to a drilled passage in the traversing pump end head and discharge it out of the oil reservoir connector port 4 through the power traversing bypass valve to port 1 of the traversing hydraulic motor. Oil entering port 1 of the traversing hydraulic motor flows through the motor end head, two back-up pistons, lower crescent in the motor flat valve, and through axial ports in the motor shaft connected to the lower crescent to force the rolling pistons passing through arc of the lower motor flat valve crescent outward, causing the inner race of the ball bearing, and the motor shaft to rotate clockwise, when facing the end of the motor shaft. Oil discharged by the motor rolling pistons, passing through the arc of the upper motor flat valve crescent, flows through axial ports in the motor shaft, motor flat valve, two back-up pistons, and out of the hydraulic motor port 2 through the power traversing bypass valve to the oil reservoir port 3. Those rolling pistons passing through the arc of the upper crescent passage in the traversing pump flat valve are sucking or filling up with oil, flowing in the reservoir port 3 and through the traversing pump end head, two back-up pistons and upper crescent in the traversing pump flat valve. Oil from the gear pump actuates a spring-loaded differential shifting piston in the traversing mechanism to close the power traversing bypass valve and flow through a solenoid-hydraulic dump valve to operate the spring loaded neutral lock plunger. It also supercharges the oil flowing to the upper crescent through the right-hand supercharge check valve. The volume of oil delivered and the clockwise rotation speed of the hydraulic transversing motor increase proportionately with the increase of eccentricity of the hydraulic traversing pump slide block assembly. Two pistons of the four-piston hydraulic dither pump, built into the elevating pump maintain an intermittent high pressure in the traversing system and set up vibrations in certain movable parts in the hydraulic traversing motor and traversing mechanism so that the hydraulic traversing motor shaft can respond instantly to the demands of the control. One piston of the dither pump,

built into the elevating pump, maintains an intermittent higher pressure at the center port of the pilot valve bushing to set up vibrations in certain movable parts in the traversing pump to provide instant response to the demands of the control. When the micro switch on the manual traversing mechanism is closed to energize the dump valve solenoid, oil from the traversing pump neutral lock cylinder and the cylinder below the bypass valve on the traversing mechanism is quickly returned to the oil reservoir. The neutral lock plunger moves upward to shift the traversing eccentric control shaft to neutral position. The plunger of the power traversing bypass valve moves downward to bypass any oil delivered to the hydraulic motor. This permits instantaneous changeover from power traversing to manual traversing of the turret.

- (9) *Counterclockwise traversing motor rotation* (fig. 62). When the electric signal control motor drives the differential in the upper control mechanism to rotate the traversing eccentric control shaft through the arc from position "A" to position "C" (fig. 62), the pilot valve plunger end of the control lever and the pilot valve plunger move to the right allowing gear pump oil to flow behind and move the large control piston, the small control piston and the slide block assembly to the right. Reciprocating motion is so imparted to the rolling pistons that those passing through the arc of the upper crescent passage in the traversing pump flat valve deliver oil to that crescent passage, to two back-up pistons, to a drilled passage in the traversing pump end head and discharge it out of the oil reservoir connector port 3 through the power-traversing bypass valve to port 2 of the traversing hydraulic motor. Oil entering port 2 of the traversing hydraulic motor flows through the motor end head, two back-up pistons, upper crescent in the motor flat valve, and through axial ports in the motor shaft connected to the upper crescent to force the rolling pistons passing through the arc of the upper motor flat valve crescent outward, causing the inner race of the ball bearing, and the motor shaft to rotate counterclockwise, when facing the end of the motor shaft. Oil discharged by the motor rolling pistons, passing through the arc of the lower motor flat valve crescent, flows through axial ports in the motor shaft, motor flat valve, two back-up pistons, and out of the hydraulic motor port 1, through the power traversing bypass valve to the oil reservoir connector

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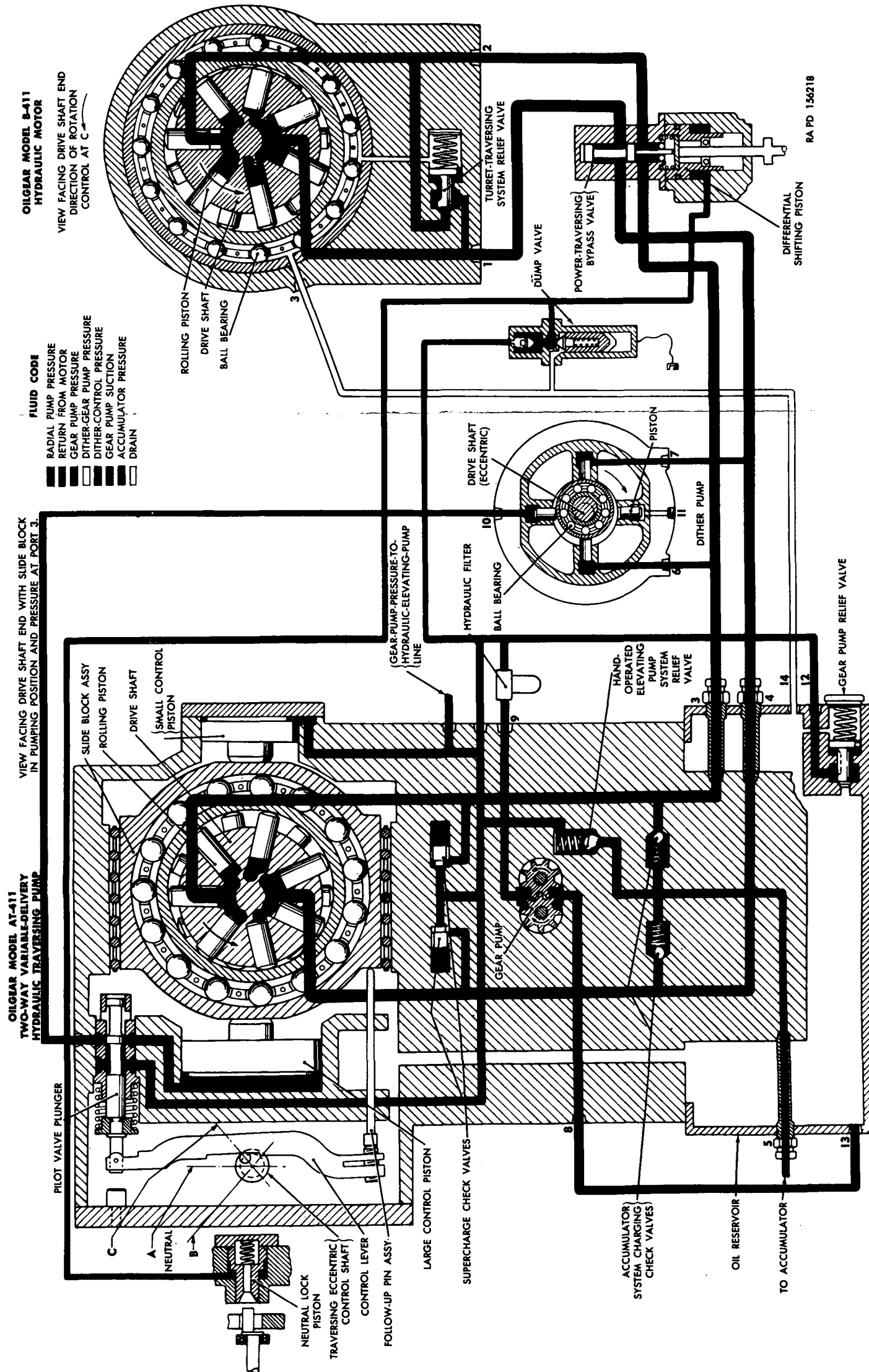


Figure 62. Hydraulic turret-traversing system oil circuit (counterclockwise).

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port 4. Those rolling pistons passing through the arc of the lower crescent passage in the traversing pump flat valve are sucking or filling up with oil flowing in the oil reservoir connector port 4 and through the traversing pump end head, two back-up pistons and lower crescent in traversing pump flat valve. Oil from the gear pump actuates a spring-loaded differential shifting piston in the traversing mechanism to close the power traversing bypass valve and flows through a solenoid-hydraulic dump valve to operate the spring loaded neutral lock plunger. It also supercharges the oil flowing to the lower crescent through the left supercharge check valve. The volume of oil delivered and the counterclockwise rotation speed of the traversing hydraulic motor increase proportionately with the increase of eccentricity of the hydraulic traversing pump slide block assembly. Two pistons of the four-piston hydraulic dither pump, built into the elevating pump, maintain an intermittent high pressure in the traversing system and set-up vibrations in certain movable parts in the traversing hydraulic motor and traversing mechanism so that the hydraulic traversing motor shaft can respond instantly to the demands of the control. One piston of the dither pump, built into the elevating pump, maintains an intermittent higher pressure at the center port of the pilot valve bushing to set up vibrations in certain movable parts in the traversing pump to provide instant response to the demands of the control. When the micro-switch on the manual traversing mechanism is closed to energize the dump valve solenoid, oil from the traversing pump neutral lock cylinder and the differential shifting cylinder below the power traversing bypass valve on the traversing mechanism is quickly returned to the oil reservoir. The neutral lock plunger moves upward to shift the traversing eccentric control shaft to neutral position. The plunger of the power traversing bypass valve moves downward to bypass any oil delivered to the hydraulic motor. This permits instantaneous change-over from power traversing to manual traversing of the turret.

c. TwoWay Variable-Delivery Elevating Pump (Oilgear Model ATT-411) (figs. 38 and 39).

(1) *Upper and lower control mechanism (fig. 63).*

Note. The key letters in this subparagraph refer to figure 63.

A fractional horsepower, direct current, variable speed, reversible electric signal motor (XX) (fig. 42), controlled by

the gunner's power traversing control handle (fig. 24) or the crew commander's control handle (fig. 20), drives the elevating pump upper control differential in either direction to actuate the elevating eccentric control shaft and the hydraulic servo-motor piston control and provide the desired speed for both elevating and depressing the gun. An actuator dummy plug (A) (fig. 51) holds the drive to the lower sun gear (J) (fig. 43) stationary. Signal motor (XX) (fig. 42) drives the signal motor shaft gear (WW), worm shaft gear (YY), control worm (AB), differential input gear (ZZ) (fig. 43), lower sun gear (PP), lower planetary gears (SS) and (RR) and upper planetary gears (TT) and (QQ), upper sun gear (UU) and feedback differential input gear (VV). When the input feedback cable (R) feedback cable pulley assembly (Q) (fig. 52), feedback shaft gear (M), differential output elevating gear (L) (fig. 43), output gear carrier (K), upper planetary gears (G) and (LL) and lower planetary gears (H) and (MM), upper sun gear (F) and feedback differential input gear (E) are stationary or rotating slower or faster than the speed demanded by lower sun gear (PP), the lower planetary gears (RR) and (SS) and the upper planetary gears (QQ) and (TT) rotate the output gear carrier (NN) to turn the elevating differential output gear (GG), elevating clutch gear (HH) (fig. 45) and elevating eccentric control shaft (EE). Counterclockwise rotation of the elevating eccentric control shaft (EE) will move the control lever (BB) (fig. 47) and the pilot valve plunger (V) inward to permit the gear pump oil to flow through the pilot valve bushing (U) to the large control piston (X) and move the slide block assembly (T) inward (to the right). As the slide block assembly (T) moves inward, the pilot valve plunger spring (W) forces one end of the control lever (BB) and the follow-up pin (DD) to follow the slide block assembly, holds the control lever (BB) against the elevating eccentric control shaft (EE) and causes the pilot valve plunger (V) to move outward and shut off the flow of gear pump oil to the large control piston (X) and stop movement of the slide block assembly (T). As long as the electric signal motor (XX) (fig. 42) continues to drive the lower sun gear (PP) (fig. 43) at a fixed speed and the input feedback cable (R) continues to rotate cable pulley assembly (Q) (fig. 52) at the selected speed, the slide block assembly (T) (fig. 47) will remain at the position selected. When the speed of the

electric signal motor (XX) (fig. 42) is increased in the same direction, the output gear carrier (NN) (fig. 43), elevating differential output gear (GG), the elevating clutch gear (HH) (fig. 45) and the elevating eccentric control shaft (EE) will turn further in a counterclockwise direction and cause the slide block assembly (T) (fig. 47) to move inward (to the right) further. When the electric signal motor (XX) (fig. 42), and the lower sun gear (PP) (fig. 43) are stopped, the lower planetary gears (RR) and (SS) and the upper planetary gears (QQ) and (TT) will cause the output gear carrier (NN), the elevating differential output gear (GG) and the elevating clutch gear (HH) to rotate the elevating eccentric control shaft (EE) (fig. 45) clockwise and move the control lever (BB) and the pilot valve plunger (V) outward. Oil behind the large control piston (X) is then free to flow through the pilot valve bushing (U) to the oil reservoir as gear pump oil moves the small control piston (S) and the slide block assembly (T) outward (to the left). As the slide block assembly (T) moves outward, the follow-up pin (DD) forces one end of the control lever (BB) outward and the opposite end inward as it pivots on the elevating eccentric control shaft (EE) fulcrum. As the pilot valve plunger (V) moves inward it shuts off the oil flow from the large control piston (X) and stops the slide block assembly (T) in neutral position. When the rotation of the electric signal motor (XX) (fig. 42) is reversed, the lower sun gear (PP) (fig. 43) drives the lower planetary gears (RR) and (SS) and the upper planetary gears (QQ) and (TT), the output gear carrier (NN), elevating differential output gear (GG) and the elevating clutch gear (HH) (fig. 45) to turn the elevating eccentric control shaft (EE) clockwise and move the control lever (BB) (fig. 47) and the pilot valve plunger (V) outward (to the left). Oil behind the large control piston (X) is then free to flow through the pilot valve bushing (U) to the oil reservoir as gear pump oil moves the small control piston (S) and the slide block assembly (T) outward (to the left). As the slide block assembly (T) moves outward, the follow-up pin (DD) forces one end of the control lever (BB) outward and the opposite end inward as it pivots on the elevating eccentric control shaft (EE) fulcrum. As the pilot valve plunger (V) moves inward it shuts off the oil flow from the large control piston (X) and stops movement of the slide block assembly (T). When the elec-

tric signal motor (XX) (fig. 42) and the lower sun gear (PP) (fig. 43) are stopped, the lower planetary gears (RR) and (SS) and the upper planetary gears (QQ) and (TT) will cause the output gear carrier (NN), the elevating differential output gear (GG) and the elevating clutch gear (HH) (fig. 45) to rotate the elevating eccentric control shaft (EE) (fig. 47) counterclockwise and move the control lever (BB) and the pilot valve plunger (V) inward. This permits the gear pump oil to flow through the pilot valve bushing (U) to the large control valve piston (X) and move the slide block assembly (T) inward (to the right). As the slide block assembly (T) moves inward, the pilot valve plunger spring (W) forces one end of the control lever (BB) and the follow-up pin (DI) to follow the slide block assembly (T) and cause the pilot valve plunger (V) to move outward and shut off the flow of gear pump oil to the large control piston (X) and stop movement of the slide block assembly (T). As long as the signal motor (XX) (fig. 42) continues to drive the lower sun gear (PP) (fig. 43) at a fixed speed and the input feedback cable (R) continues to rotate the cable pulley assembly (Q) (fig. 52) at the selected speed, the slide block assembly (T) will remain at the position selected. The several control movements, such as the electric signal motor drive, the input feedback cable drive and the elevating eccentric control shaft angular rotation, have been described as occurring in sequence but actually they all move and stop substantially in synchronism. Gun elevating, depressing and stopping responds immediately to the demands of the electric signal motor and the differential control. The feedback cable (R) is fastened to breechlock end of the gun. Feedback shaft spring (N) (fig. 52) maintains constant tension on the feedback cable (R) and drives the feedback shaft gear (M) when the gun is elevating and the feedback cable (R) feeds back on pulley (Q). When the power pack is installed in the tank, the actuator dummy plug (A) (fig. 51) and the elevating control upper case cover is removed and a superelevating device is mounted on the elevating control upper case to drive the superelevating coupling pin (B) and the superelevating input gear (C), the superelevating differential input gear (D) and the lower sun gear (J) (fig. 43). When the superelevating device operates the gun elevating control, the electric signal motor (XX) (fig. 42) and drive to lower sun gear (PP) (fig. 43) remain stationary. The

[REDACTED]

superelevating device drives the superelevating coupling pin (B) (fig. 51), superelevating input gear (C), superelevating differential input gear (D), lower sun gear (J) (fig. 43), lower planetary gears (H) and (MM) and upper planetary gears (G) and (LL), upper sun gear (F) and differential feedback input gear (E). When the input feedback cable (R), feedback pulley assembly (Q) (fig. 52), feedback shaft gear (M), differential elevating output gear (L) (fig. 43) and the output gear carrier (K) are stationary or rotating slower or faster than the speed demanded by the lower sun gear (J), the upper planetary gears (G) and (LL) and the lower planetary gears (H) and (MM) rotate the upper sun gear (F) and the feedback differential input gear (E) to turn the feedback differential input gear (VV), upper sun gear (UU), lower planetary gears (RR) and (SS) and upper planetary gears (QQ) and (TT), output gear carrier (NN), elevating differential output gear (GG), elevating clutch gear (HH) (fig. 45) and elevating eccentric control shaft (EE). The principle of operation of the elevating eccentric control shaft (EE) (fig. 47), control lever (BB), pilot valve plunger (V), slide block assembly (T) and follow-up pin (DD) is the same as previously described for the electric signal motor control. Clutch limit plate (JJ) (fig. 45) and clutch limit plate pin (KK) limit the angular movement of the elevating eccentric control shaft (EE) (fig. 47) to the maximum slide block assembly (T) stroke. Clutch spring (FF) (fig. 45) maintains a present contact between the elevating clutch gear (HH) and the clutch limit plate (JJ). Elevating clutch gear (HH) can slip on the clutch limit plate (JJ) when sudden surges or reversals of control occur, when the clutch limit plate reaches maximum angular rotation in either direction or when the gun is elevated or depressed manually. Pilot valve plunger spring (W) (fig. 47) eliminates play between the pilot valve plunger (V) and the control lever (BB) and keeps the control lever (BB) tight against the elevating eccentric control shaft (EE). An adjustment is provided between the control lever (BB) and the follow-up pin (DD) for selecting the neutral position. Pilot valve plunger (V) has a close negative seal fit with the center port in the pilot valve bushing (U) to eliminate hunting of the hydraulic servo-motor piston control. When the power pack electric drive motor is shut off, and the gear pump pressure in the neutral lock cylinder (Y) (fig. 53) drops, the neutral lock

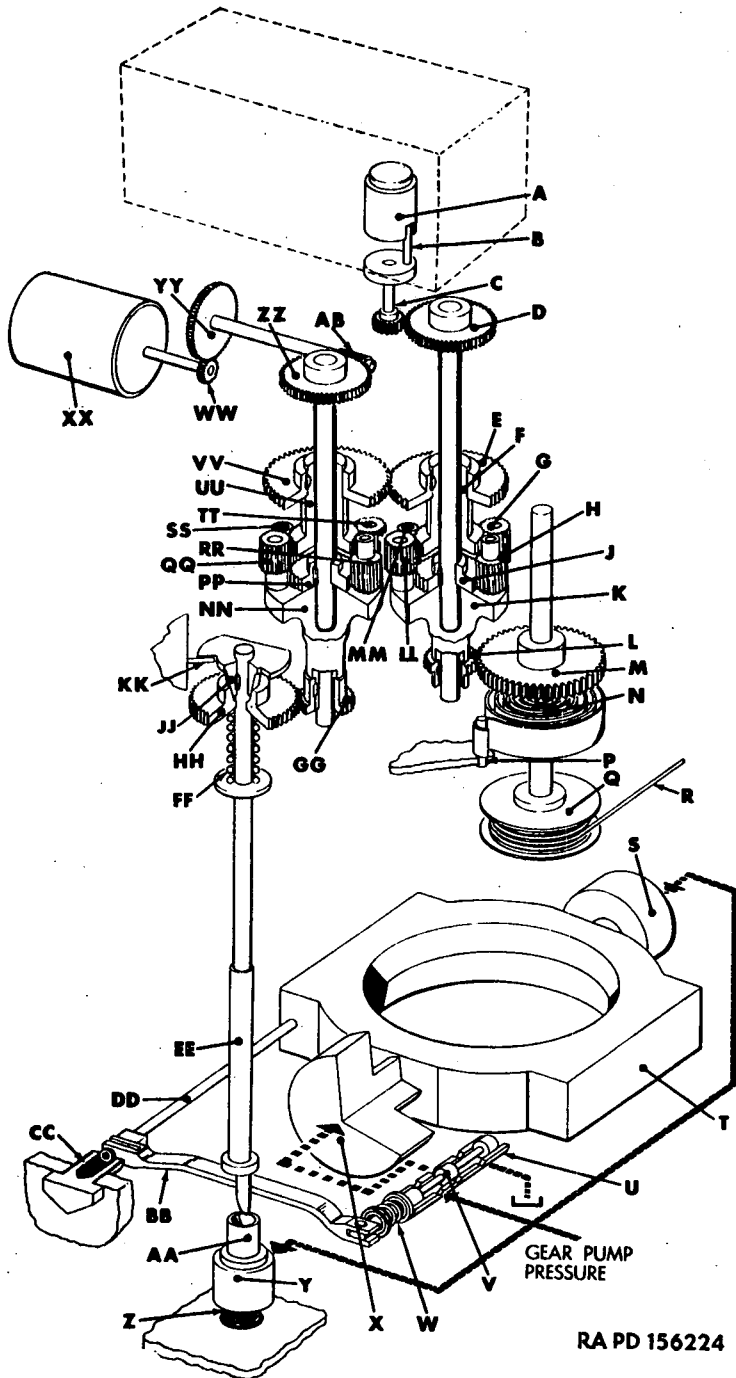


Figure 63. Gun-elevating hydraulic pump control—schematic isometric diagram.

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Figure 68—Continued

A—PLUG, DUMMY, ACTUATOR—7353119
B—PIN, COUPLING, SUPER-ELEVATING—7352031
C—GEAR, INPUT, SUPERELEVATING—7352046
D—GEAR, INPUT, SUPERELEVATING DIFFERENTIAL—7352057
E—GEAR, DIFFERENTIAL FEEDBACK INPUT—7352025
F—GEAR, SUN, UPPER—7737579
G—GEAR, PLANETARY, UPPER—7737572
H—GEAR, PLANETARY, LOWER—7737572
J—GEAR, SUN, LOWER—7737571
K—CARRIER, OUTPUT GEAR—7737578
L—GEAR, ELEVATING, DIFFERENTIAL OUTPUT—7352023
M—GEAR, FEEDBACK SHAFT—7353114
N—SPRING, FEEDBACK SHAFT—7353094
P—CASE, ELEVATION CONTROL, LOWER—7353171
Q—PULLEY, ASSY—7737502
R—CABLE, FEEDBACK
S—PISTON, CONTROL, SMALL—7352035
T—BLOCK, SLIDE, ASSY—7353139
U—BUSHING, PILOT VALVE—7352028
V—PLUNGER, PILOT VALVE—7352029
W—SPRING, ELEVATING PILOT VALVE PLUNGER—7737543
X—PISTON, CONTROL, LARGE—7352034
Y—CYLINDER, NEUTRAL LOCK—7737584
Z—SPRING, NEUTRAL LOCK—7010227
AA—PLUNGER, NEUTRAL LOCK—7010228
BB—LEVER, CONTROL—7353142
CC—CAP, FOLLOW-UP LEVER—7353121
DD—PIN, FOLLOW-UP—7352032
EE—SHAFT, ELEVATING ECCENTRIC—7737544
FF—SPRING, SLIP CLUTCH—7353116
GG—GEAR, ELEVATING DIFFERENTIAL OUTPUT—7352023
HH—GEAR, ELEVATING CLUTCH—7737542
JJ—PLATE, CLUTCH LIMIT—7352030
KK—PIN, DOWEL—A244981
LL—GEAR, PLANETARY, UPPER—7737572
MM—GEAR, PLANETARY, LOWER—7737572
NN—CARRIER, OUTPUT GEAR—7737578
PP—GEAR, SUN, LOWER—7352022
QQ—GEAR, PLANETARY, UPPER—7737572
RR—GEAR, PLANETARY, LOWER—7737572
SS—GEAR, PLANETARY, LOWER—7737572
TT—GEAR, PLANETARY, UPPER—7737572
UU—GEAR, SUN, UPPER—7737579
VV—GEAR, DIFFERENTIAL FEEDBACK INPUT—7352025
WW—GEAR, SIGNAL MOTOR SHAFT—7369581
XX—MOTOR, SIGNAL, ASSY—7383151
YY—GEAR, WORM SHAFT—7737551
ZZ—GEAR, DIFFERENTIAL INPUT—7352053
AB—WORM, CONTROL—7352052

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plunger spring (Z) raises the neutral lock plunger (AA) to lock the elevating eccentric control shaft (EE) in the neutral position. If the elevating eccentric control shaft (EE) and the slide block assembly (T) are on stroke, the cone-shaped hole in the neutral lock plunger (AA) forces the elevating eccentric control shaft (EE) to the neutral position and holds it there. This safety feature prevents the control from being on stroke and the gun from elevating or lowering unexpectedly when the power pack is started.

- (2) *Radial piston pump* (figs. 47 and 54). The gun-elevating pump shaft, with 14 radial cylinders having closely fitted rolling pistons and 7 axial ports, is driven clockwise by an electric drive motor through an electric motor drive gear and elevating pump drive gear. Centrifugal force, combined with the pressure in the hydraulic elevating system, keeps the beveled surfaces of the rolling pistons against the inner race of the slide block ball bearing assembly. Through contact of the rolling pistons, the inner race of the slide block assembly rotates with the elevating pump shaft. The slide block assembly, which moves on two slide block caged rollers between ground surfaces on the slide block assembly and the slide block roller plates in the pump case, is moved to the right of the elevating pump shaft axis by a large control piston and to the left of the elevating pump shaft axis by a small control piston. Increasing the eccentricity of the slide block assembly increases the stroke of the rolling pistons and the volume of oil discharged. Reversing the eccentricity of the slide block assembly reverses the direction of oil flow. When the center-line of the elevating pump shaft and the slide block assembly do not coincide, the differences between the radii from the center of the elevating pump shaft to the points of contact of the rolling pistons with the inner race of the slide block assembly cause the rolling pistons to move faster or slower than their points of contact with the inner race of the slide block assembly. This difference in speed is adjusted by a slow, partial rotation of each rolling piston in its elevating pump shaft bore—in one direction during the one-half revolution and in the opposite direction during the other half revolution. The rolling pistons thus rotate and reciprocate, simultaneously. Oil flows to and from the rolling pistons through machined passages in the elevating pump end head, back-up pistons, elevating pump flat valve and elevating pump shaft.

FLUID CODE	
	GEAR PUMP PRESSURE
	HAND PUMP SUCTION
	ACCUMULATOR PRESSURE
	CONTROL PRESSURE
	DRAIN
	DITHER-GEAR PUMP PRESSURE
	DITHER-CONTROL PRESSURE

**OILGEAR MODEL ATT-411
TWO-WAY VARIABLE-DELIVERY
HYDRAULIC ELEVATING PUMP**

VIEW FACING DRIVE SHAFT END
WITH SLIDE BLOCK IN NEUTRAL POSITION

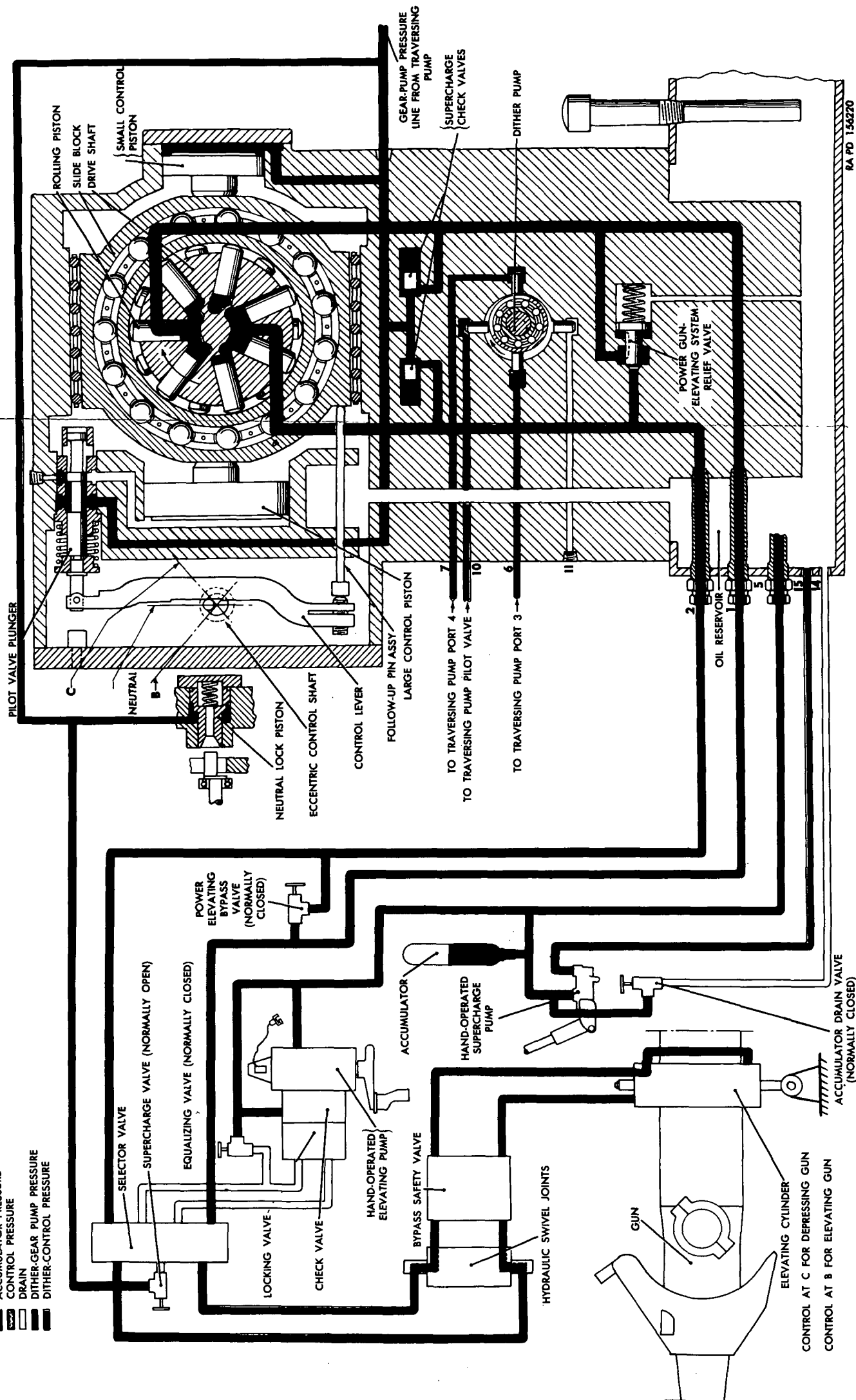


Figure 64. Hydraulic gun-elevating system oil circuit (neutral).

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- (3) *Dither pump* (figs. 54 and 55). Two of the four closely fitted, supercharged, positive-delivery dither pump pistons, one connected to port 6 and the other to port 7, alternately withdraw oil from and inject oil into the traversing system at a rapid rate to create pulsations of pressure. These pulsations maintain an intermittent high pressure in the system and set up vibrations in certain movable parts so that the hydraulic traversing motor shaft can respond instantly to the demands of the control. One of the dither pistons, connected to port 10, withdraws oil from and injects oil into the center port of the traversing hydraulic pump pilot valve bushing to set up vibrations in certain movable parts in the traversing pump to provide instant response to the demands of the control. The other dither piston remains dormant and port 11 is plugged.
- (4) *Auxiliary relief valve and check valves* (figs. 49, 54, and 56). Built into the elevating pump end head is a reverse flow type relief valve (fig. 56) which limits the pressure generated by the two-way variable-delivery hydraulic elevating pump or some external force on gun. Two spring-loaded disc type check valves (fig. 49) permit gear pump to supercharge the elevating radial piston pump and elevating cylinder.
- (5) *Oil reservoir* (figs. 38 and 39). Refer to paragraph 28g.
- (6) *Neutral* (fig. 64). When the elevating eccentric control shaft is in neutral position, the centerlines of the elevating pump shaft and slide block assembly coincide and no reciprocating motion is imparted to the rolling pistons. Thus, as the elevating pump shaft and pumping unit rotate, no oil is delivered by the elevating pump to the elevating cylinder, so the gun remains stationary. Oil delivered by the gear pump lubricates and supercharges the radial piston pump and the elevating cylinder system. Two pistons of the four-piston hydraulic dither pump, connected to ports 6 and 7, maintain an intermittent high pressure in the traversing system and set-up vibration in certain movable parts in the traversing mechanism so that the traversing hydraulic motor can respond instantly to the demands of the control. The dither piston connected to port 10 maintains an intermittent higher pressure in the center port of the traversing pump pilot valve bushing. The dither piston connected to port 11 is inactive.
- (7) *Elevating gun* (fig. 65). When the electric signal control motor or superelevating device drives either differential in

the upper control mechanism to rotate the elevating pump eccentric control shaft through the arc from position "A" to position "B" (fig. 65), the pilot valve plunger end of the control lever and the pilot valve plunger move to the left allowing oil behind the large control piston to flow out the pilot valve bushing to the oil reservoir as the gear pump oil moves the small control piston, slide block assembly and large control piston to the left. Reciprocating motion is so imparted to the rolling pistons that those passing through the arc of the upper crescent passage in the elevating pump flat valve deliver oil to that crescent passage, to two back-up pistons, to a drilled passage in the elevating pump end head and discharge it out of the oil reservoir port 1 through the selector valve, hydraulic swivel joint, bypass safety valve, to the lower end of the elevating cylinder. Oil entering the lower end of the elevating cylinder forces the cylinder and the breechlock end of the gun downward, elevating the gun barrel. Oil discharged out of the upper end of the elevating cylinder flows through the bypass safety valve, hydraulic swivel joint and selector valve to the oil reservoir port 2. Those rolling pistons passing through the arc of the lower crescent passage in the elevating pump flat valve are sucking or filling up with oil flowing in the oil reservoir port 2 and through the elevating pump end head, two back-up pistons and the lower crescent in the elevating pump flat valve. Oil from the gear pump supercharges the oil flowing to the lower crescent through the left supercharge check valve. The volume of oil delivered and the speed of gun elevating increase proportionately with the increase of eccentricity of the hydraulic elevating pump slide block assembly. Three of the four pistons in the hydraulic dither pump maintain an intermittent high pressure in the traversing system and the traversing pump pilot valve control system.

- (8) *Depressing gun* (fig. 66). When the electric signal motor or superelevating device drives either differential in the upper control mechanism to rotate the elevating pump eccentric control shaft through the arc from position "A" to position "C" (fig. 66), the pilot valve plunger end of the control lever and the pilot valve plunger move to the right allowing gear pump oil to flow behind and move the large control piston, the small control piston and slide block assembly to the right. Reciprocating motion is so imparted to the rolling pistons that those passing through the arc of the lower cres-

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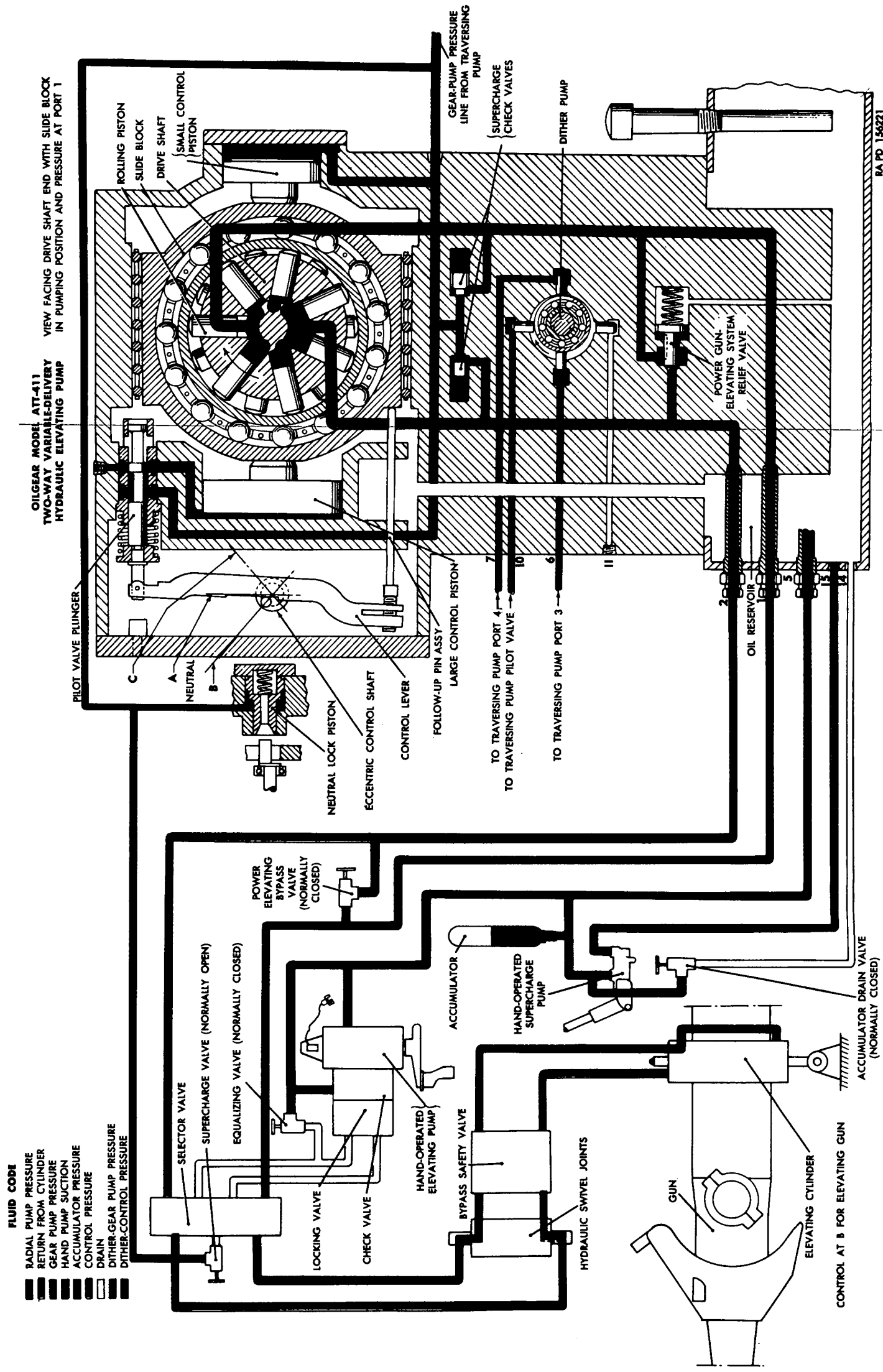


Figure 65. Hydraulic gun-elevating system oil circuit (elevating).

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**OILGEAR MODEL ATT-411
TWO-WAY VARIABLE-DELIVERY
HYDRAULIC ELEVATING PUMP**

VIEW FACING DRIVE SHAFT END WITH SLIDE BLOCK
IN PUMPING POSITION AND PRESSURE AT PORT 2

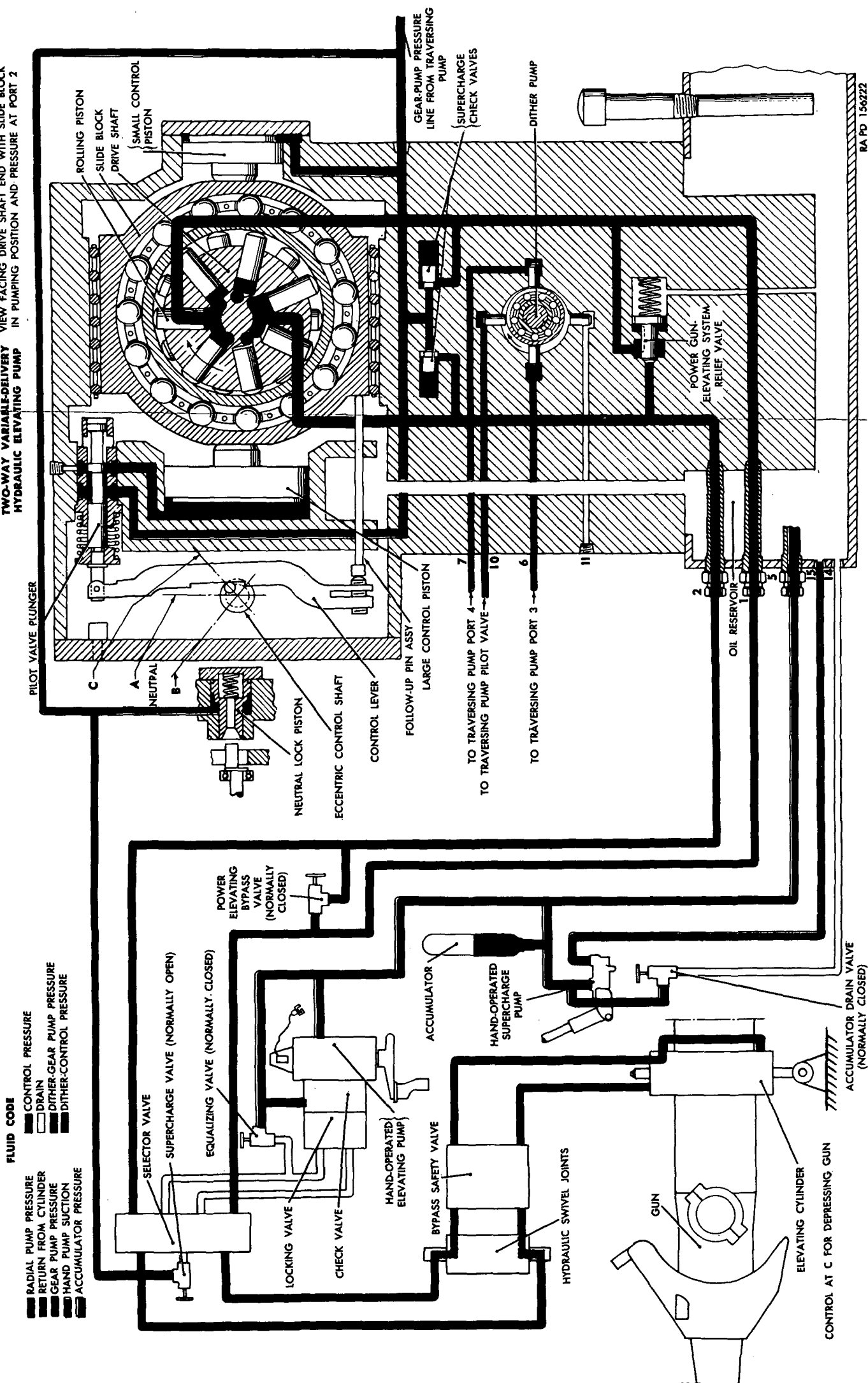


Figure 66. Hydraulic gun-elevating system oil circuit (depressing).

cent passage in the elevating pump flat valve deliver oil to that crescent passage, to two back-up pistons, to a drilled passage in the elevating pump end head and discharge it out of the oil reservoir port 2 through the selector valve, hydraulic swivel joint, bypass safety valve, to the upper end of the elevating cylinder. Oil entering the upper end of the elevating cylinder forces the cylinder and the breechblock end of the gun upward, depressing the gun barrel. Oil discharged out the lower end of the elevating cylinder flows through the bypass safety valve, hydraulic swivel joint, and selector valve to the oil reservoir port 1. Those rolling pistons passing through the arc of the upper crescent passage in the elevating pump flat valve are sucking or filling up with oil flowing in the oil reservoir port 1 and through the elevating pump end head, two back-up pistons and the upper crescent in the elevating pump flat valve. Oil from the gear pump supercharges the oil flowing to the upper crescent through the right-hand supercharge check valve. The volume of oil delivered and the speed of gun depressing increase proportionately with the increase of eccentricity of the hydraulic elevating pump slide block assembly. Three of the four pistons in the hydraulic dither pump maintain an intermittent high pressure in the traversing system and the traversing pump pilot valve control system.

30. Data

a. Power Pack.

Power pack:

Make.....	Oilgear
Ordnance part number.....	7737710
Net weight.....	266 lb

Electric drive motor:

Make.....	A. O. Smith Corp.
Model.....	D-9004
Ordnance part number.....	7386699
Rated speed (full load).....	3,800 rpm
Rated speed (idle).....	4,700 to 5,500 rpm
Rated power.....	5 hp
Operated voltage (dc).....	24-28 volts
Rotation (as viewed from drive end).....	clockwise
Weight.....	85 lb

Electric signal motor:

Make	Minneapolis-Honeywell
Model	G-2059A1
Ordinance part number	7737553
Voltage (dc)	24-28 volts
Speed	12,000 rpm
Rotation	reversible

Turret-Traversing Hydraulic Pump:

Make	oilgear
Model	AT-411
Ordinance part number	7737556
Theoretical delivery per revolution	0.680 cu-in.
Input speed (full load)	3,800 rpm
Traversing system relief valve setting (blowing aprx 350 cipm) 2,100 to 2,400 psi	
Accumulator system relief valve setting (blowing aprx 400 cipm)	2,000 to 2,300 psi
Gear pump capacity (at neutral and 120 psi)	375 cipm
Net weight	65 lb

Gun-elevating hydraulic pump:

Make	oilgear
Model	ATT-411
Ordinance part number	7737557
Theoretical delivery per revolution	0.340 cu-in
Input speed (full load)	1,000 rpm
Elevating system relief valve setting (blowing aprx 400 cipm) 1,400 to 1,700 psi	
Net weight	71 lb

Oil reservoir:

Make	oilgear
Ordinance part number	7353180
Capacity	1½ gal
Gear pump relief valve (blowing)	110 to 130 psi
Grade of oil—Refer to lubrication order	(LO 9-718A)
Net weight	31 lb

b. *Port Data.* Refer to table II for port data.

Table II. Power Pack Ports

Port	Tap size (in.)	Tube size (in.)	Port description	Port connected to—
1	1/16-18NF-3---	3/8	High-pressure connection from elevating pump.	Selector valve port 1.
2	1/16-18NF-3---	3/8	do-----	Selector valve port 2.
3	1/4-16NF-3-----	1/2	High-pressure connection from traversing pump.	Power traversing bypass valve.
4	1/4-16NF-3-----	1/2	do-----	Do.
5	1/16-20NF-3-----	1/4	High-pressure connection from elevating pump.	Accumulator and hand-operated supercharge pump outlet port.
6	1/16-20NF-3-----	1/4	High-pressure connection from dither pump.	Line connecting traversing pump port 4 and power traversing bypass valve port.
7	1/16-20NF-3-----	1/4	do-----	Line connecting traversing pump port 3 and power traversing bypass valve port.
8	1/2 pipe tape----	5/8	Gear pump suction----	Reservoir port 13.
9	3/8 pipe tape----	1/2	Gear pump pressure----	Reservoir port 12. Dump valve port. Traversing mechanism port shifting mechanism. Selector valve boost port. Traversing pump neutral lock cylinder.
10	1/16-20NF-3-----	1/4	High-pressure connection from dither pump.	Center port of traversing pump pilot valve bushing.
11	1/16-20NF-3-----	1/4	High-pressure connection from dither pump (plugged).	
12	3/8 pipe tap-----	1/2	Gear pump relief valve	Traversing pump port 9.
13	1/2 pipe tap-----	5/8	Gear pump suction----	Traversing pump port 8.
14	1/16-20NF-3-----	1/4	Drain connection*----	Traversing hydraulic motor port 3.
15	1/16-18NF-3-----	3/8	Hand-operated supercharge pump suction.	Hand-operated supercharge pump inlet port.

*4 additional drain connections of this size are provided on the oil reservoir.

Section III. HYDRAULIC MOTOR (OILGEAR MODEL B-411)

31. Construction

(fig. 67)

a. General. The constant-displacement hydraulic motor (Oilgear Model B-411) consists essentially of a radial piston motor unit, a motor flat valve and end head assembly, a traversing system relief valve and a motor case and cover to inclose the mechanism. It is mounted on top of the traversing mechanism.

b. Radial Piston Motor (figs. 68 and 69). The hydraulic case cover, motor case and motor end head (fig. 68) incloses a balanced motor flat valve, a ported motor shaft with 14 radial cylinders mounted on anti-friction front and rear ball bearings, 14 rolling pistons closely fitted to radial cylinders in the motor shaft and a piston reaction ball bearing with double beveled inner race. As fluid from the hydraulic traversing pump enters the hydraulic motor, the ported motor shaft rotates on front and rear antifriction ball bearings. Oil under pressure below the rolling pistons, plus centrifugal force, keeps the beveled surfaces of the rolling pistons against the beveled inner race of the piston reaction ball bearing. The outer race of the piston reaction ball bearing is fitted in the hydraulic motor case at a fixed eccentricity to the centerline of the motor shaft to provide piston stroke (fig. 69). The inner race of the piston reaction ball bearing rotates with the motor shaft through contact of the rolling pistons.

c. Motor Flat Valve and End Head (fig. 68). Four springs hold the four back-up pistons in the motor end head against the motor flat valve. Two equalizer pistons in the motor flat valve balance the hydraulic force which tends to separate the motor flat valve from the end of the motor shaft. The valve locating pins pressed into the motor end head and a retaining ring hold motor flat valve in place for convenience in assembly.

d. Traversing System Relief Valve (fig. 70). The traversing system two-way, reverse-flow-type relief valve, consisting essentially of a bushing plunger, spring, spring guide, shims, and O ring gaskets, is built into the motor end head.

32. Principle of Operation

a. General. Oil delivered by the two-way, variable-delivery hydraulic pump (Oilgear model AT-411) through the normally closed power traversing bypass valve on the traversing mechanism flows to and from the traversing hydraulic motor mounted on top of the tra-

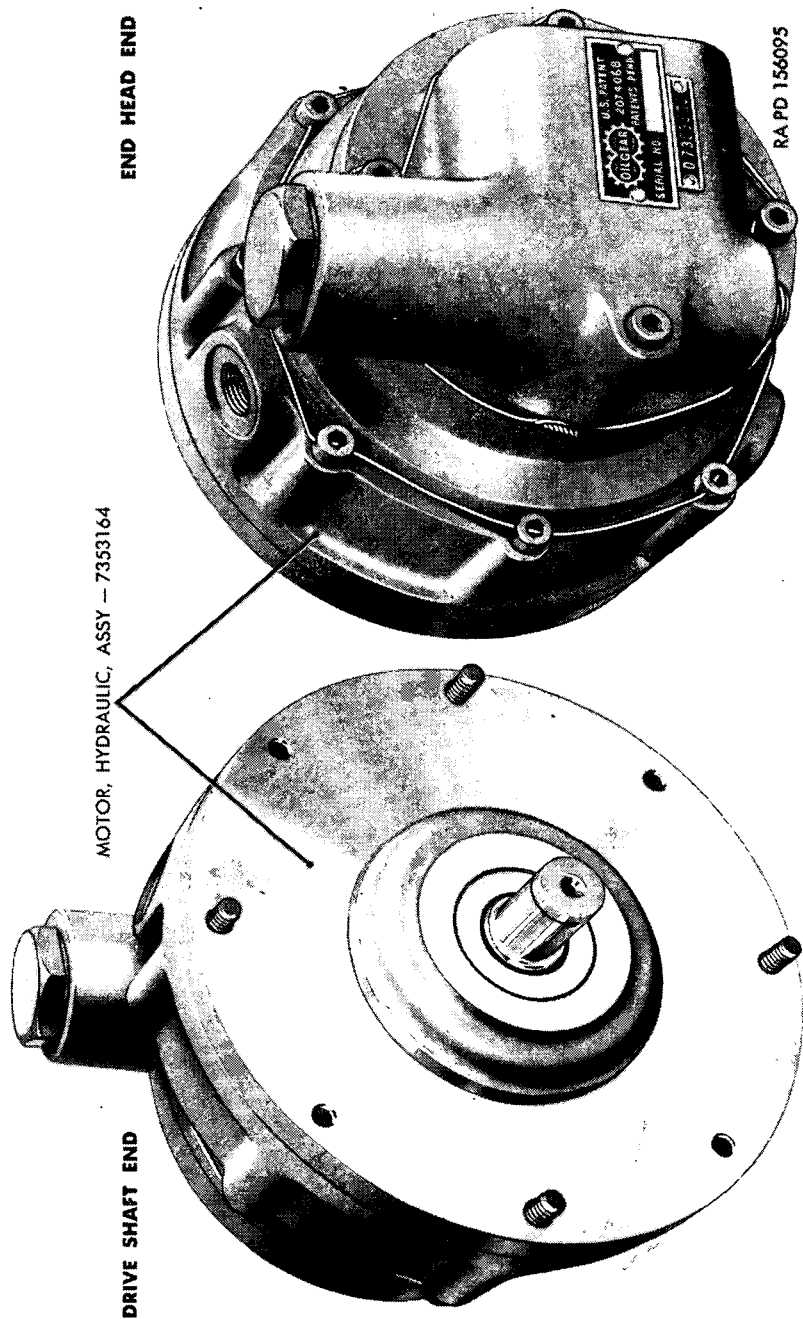
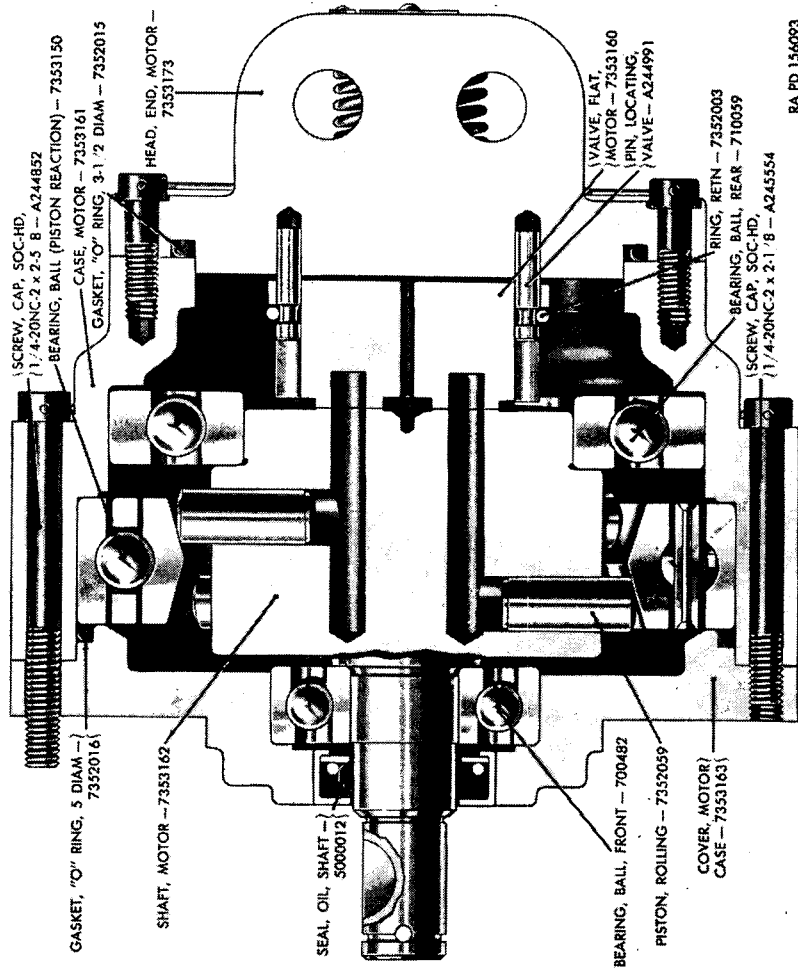


Figure 67. Constant-displacement hydraulic traversing motor—front and rear views.



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Figure 68. Constant-displacement hydraulic traversing motor—side-elevation cross section.

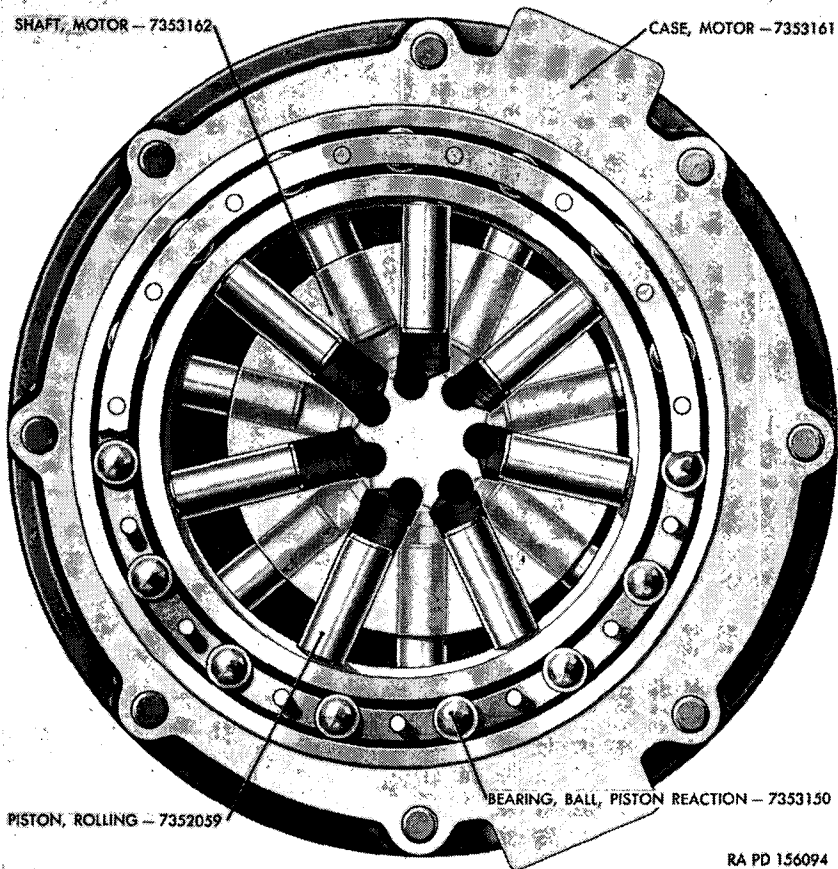
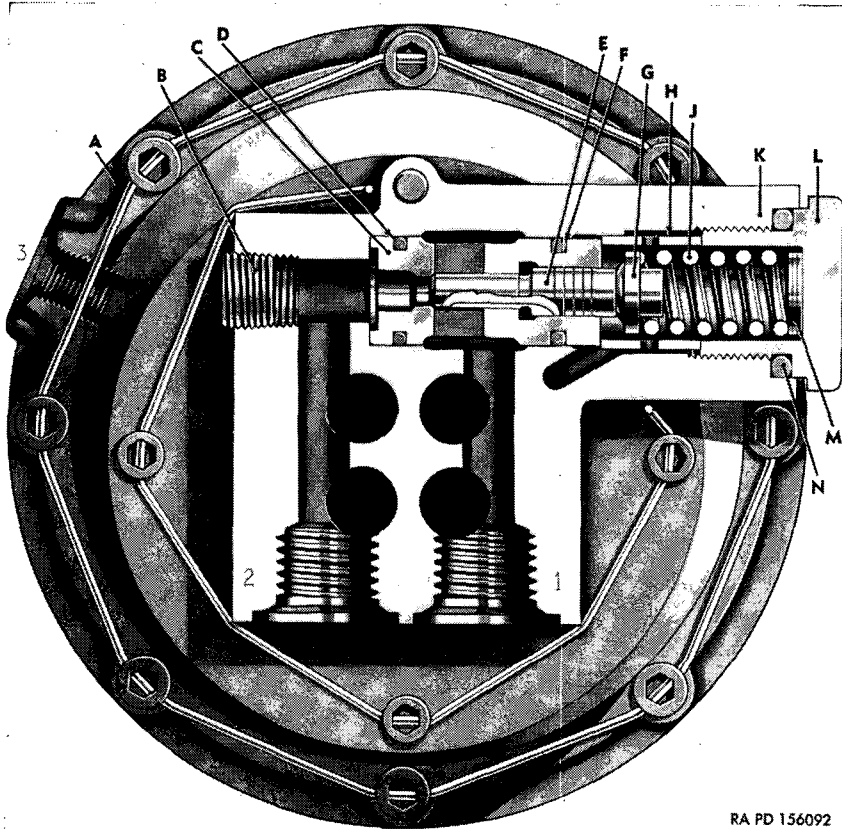


Figure 69. Constant-displacement hydraulic traversing motor—front elevation cross section.

versing mechanism to power drive the traversing mechanism and turret in either direction.

b. Radial Piston Motor (figs. 68 and 69). The hydraulic motor shaft, with 14 radial cylinders having closely fitted rolling pistons and 7 axial ports (fig. 68), is driven clockwise or counterclockwise by oil under pressure delivered by the two-way, variable-delivery hydraulic traversing pump through the normally closed bypass valve. Since the centerlines of the ported motor shaft and the piston reaction ball bearing do not coincide (fig. 69), the differences between the radii from the center of the motor shaft to the points of contact of the rolling pistons with the inner race of the piston reaction ball bearing cause the rolling pistons to move faster or slower than their points of



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Figure 70. Constant-displacement hydraulic traversing motor relief valve—rear elevation cross section.

- A—CASE, MOTOR—7353161
- B—PLUG, PIPE, SOCKET HEAD, 1/4—444691
- C—BUSHING, RELIEF VALVE—7352010
- D—GASKET, O RING, BUSHING, INNER—7352008
- E—PLUNGER, RELIEF VALVE—7352013
- F—GASKET, O RING, BUSHING, OUTER—7352008
- G—GUIDE, RELIEF VALVE SPRING—7352007
- H—SPACER, RELIEF VALVE—7352011
- J—SPRING, RELIEF VALVE—A244950
- K—HEAD, END, MOTOR—7353173
- L—CAP, RELIEF VALVE—7352012
- M—SHIM (VARIOUS THICKNESSES)
 - 0.062—A244967
 - 0.020—7069791
 - 0.005—7069789
 - 0.031—7069792
 - 0.010—7069790
 - 0.093—7069793
- N—GASKET, O RING, CAP—7352005

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contact with the inner ring of the piston reaction ball bearing. This difference in speed is adjusted by slow, partial rotation of each rolling piston in its bore—in one direction during one-half revolution and in the opposite direction during the other half revolution of motor shaft. Thus, the rolling pistons rotate and reciprocate simultaneously. Centrifugal force, plus the pressure in the system keeps the rolling pistons in contact with the inner race of the piston reaction ball bearing. Internal slip and leakage lubricates the working parts and then drains out of the hydraulic port 3 of the oil reservoir through port 14.

c. *Motor Flat Valve and End Head* (fig. 68). Spring and hydraulic pressure hold the back-up pistons against the motor flat valve and the valve against the ported end of the motor shaft. Hydraulic pressure on the two equalizer pistons balance the hydraulic forces which tend to separate the motor flat valve from the end of the motor shaft. One crescent in the motor flat valve is connected to motor port 1 through two back-up pistons and the other crescent is connected to motor port 2 through two other back-up pistons. Oil is delivered to and received from the axial ports and radial pistons in the motor shaft through the two crescents.

d. *Traversing System Relief Valve* (fig. 70). Oil in the motor port 1 acts on the differential area of the relief valve plunger through an axial "V" groove on the small diameter of the plunger. Oil in the motor port 2 acts on the small end area of the relief valve plunger. Both areas are approximately equal. When the pressure in the motor port 1 exceeds the setting of the relief valve spring, oil flows through the "V" groove to lift the plunger off its seat and the oil discharges past the end of the plunger to the motor port 2. When the pressure in the motor port 2 exceeds the setting of the relief valve spring, it lifts the plunger off its seat and the oil discharges past the end of the plunger to the motor port 1.

e. *Clockwise Rotation*. Oil delivered from the traversing pump port 4 through the normally closed power traversing bypass valve to the hydraulic motor port 1 (fig. 61) flows through the end head, two back-up pistons, lower crescent in the motor flat valve, and those axial ports in the motor shaft connected to the lower crescent to force the rolling pistons passing through the arc of the lower crescent in the motor flat valve outward, causing the inner race of the piston reaction ball bearing, and motor shaft to rotate clockwise, when facing the output end of the hydraulic motor shaft. Oil discharged by the hydraulic motor rolling pistons passing through the arc of the upper crescent in the motor flat valve flows through the ports in the motor shaft, motor flat valve, two back-up pistons and out the hydraulic

motor port 2 through the power traversing bypass valve, back to the traversing pump port 3.

f. Counterclockwise Rotation. Oil delivered from the hydraulic traversing pump port 3 through the normally closed power traversing bypass valve to the hydraulic motor port 2 (fig. 62) flows through the end head, two back-up pistons, upper crescent in the motor flat valve, and those ports in the motor shaft connected to the upper crescent, to force the rolling pistons passing through the arc of the upper crescent in the motor flat valve outward, causing the inner race of the piston reaction ball bearing, and motor shaft to rotate counterclockwise, when facing the output end of the hydraulic motor shaft. Oil discharged by the hydraulic motor rolling pistons and passing through the arc of the lower crescent in the motor flat valve flows through ports in the motor shaft, motor flat valve, two back-up pistons, and out the hydraulic motor port 1 through the power traversing bypass valve, back to the hydraulic traversing pump port 4.

33. Data

a. General.

Make	Oilgear
Model No.	B-411
Ordinance part number	7353164
Theoretical displacement per revolution	0.657 cu in
Eccentricity of piston reaction ball bearing	0.181 in
Motor output speed at 3,800 rpm pump input speed	3,600 rpm
Traversing relief valve setting (blowing aprx. 350 cipm)	2,000 to 2,300 psi
Maximum torque at 2,000 psi	180 lb-in
Net weight	22 1/2 lb

b. Port Data. Refer to Table III for port data.

Table III. Hydraulic Motor Ports

Port	Tap size (in.)	Tube size (in.)	Port description	Port connected to—
1	3/4-16NF-3	1/2	High-pressure inlet for clockwise rotation, when facing drive shaft end.	Power traversing bypass valve port.
2	3/4-16NF-3	1/2	do	Do.
3	7/16-20NF-3	1/4	Case drain	Oil reservoir port 14.

CHAPTER 5

TRAVERSING MECHANISM, HAND DRIVE, AND SHIFTING MECHANISM

Section I. DESCRIPTION

34. General

a. Requirements. Requirements for a traversing mechanism demand a reliable antilash driving gear mechanism which will perform rapid precision-tracking of all ground combat targets. The traversing mechanism must drive the turret through a range of angular speeds, varying from 0.3 mil per second to four revolutions a minute. The mechanism in addition, provides selective control of either power operation supplies by a hydraulic motor or of manual operation by the gunner. The shifting mechanism is capable of connecting or isolating the hand drive within one to two seconds and must automatically revert to manual operation should power operation fail.

b. Traversing mechanism. The traversing mechanism for the turret (fig. 71) is comprised of the main support housing (M, fig. 71), spherical bearing caps (N and P, fig. 71), planetary gear housing (R, fig. 71), motor support housing (T, fig. 71), lower adapter housing (CC, fig. 71), upper adapter housing (AA, fig. 71), and the gear assemblies enclosed therein. The traversing mechanism contains an anti-lash mechanism and supports the entire gear assembly, the hand drive, the shifting mechanism, and the hydraulic drive motor to the turret. The lash-eliminating assembly for accurate turret-tracking consists of a spring and gear assemblies (JJ, KK, and LL, fig. 73). Dual planetary reduction systems provide a reduction of 600 to 1 between the drive motor and turret, allowing efficient hydraulic motor speeds to be employed to obtain the desired range of turret traversing rates. The reduction ratio from the traverse drive motor gear (BB, fig. 71) to the traverse pinion gears (E, fig. 72) is 28.57 to 1.

c. Traversing Hand Drive. The traversing hand drive contains mechanisms to protect the gunner and the internal reduction gear assemblies which allow the gunner rapid manual traverse without

fatigue. The hand drive is mounted to the traversing mechanism, supports the shifting mechanism and places the handle in a convenient manual operating position. The handle to turret reduction ratio is 471 to 1 and the reduction ratio from the handle (B, fig. 71) to the output pinion gears (E, fig. 72) is 22.429 to 1. The hand drive is composed of the idler gear housing (L, fig. 71), idler gear housing cover (W, fig. 71), bearing cap cover (DD, fig. 71), no-back housing (J, fig. 71), bevel gear housing (G, fig. 71), hand crank housing (E, fig. 71), the traverse crank arm (C, fig. 71), and traverse crank handle (B, fig. 71), with the enclosed gears. The hand drive includes the no-back lock (G, H, J, and K, fig. 73) and a lock ring and pin shown in figure 74. The lock ring encloses the lock bar and no-back lock spring and is concentrically held by the no-back housing (J, fig. 71), in position by the ring locking pin (fig. 74). A slip clutch assembly in the hand drive (M, N, P, Q, and R, fig. 73) is bearing-mounted within a sleeve fastened within the idler gear housing (L, fig. 71).

35. Construction

a. General. The traversing mechanism, hand drive, and shifting mechanism assemble into approximately 15 machined housings which are doweled and bolted together into a sandwich-type unit to permit disassembly for repair, adjustment, or replacement. The housings form a unit assembly shaped to occupy a restricted area in the turret and enclose gears to provide power and durability. The gears and bearings are completely enclosed and lubricated with the exception of the traversing pinion gears (E, fig. 72) which mesh with the turret ring gear.

b. Main Support Housing. The main support housing (M, fig. 71) supports the main shaft assemblies (GG and SS, fig. 73) and the traverse pinion gears (HH and TT, fig. 73). Two spherical bearings support the traversing pinion gear-end of the main shaft assemblies. Two vertical mounting bolt holes (A, fig. 72) and three horizontal holes (D, fig. 72), through a large machine radius (C, fig. 72), allow two $\frac{3}{4}$ -16NF-2 x 4 223833 bolts, one $\frac{1}{2}$ -20UNF-2A x 4 223715 bolt, and two $\frac{1}{2}$ -20UNF-2A x $2\frac{3}{8}$ 224019 bolts to secure and support the complete traversing mechanism, hand drive, and shifting mechanism with a locating keyway (B, fig. 72) on the mounting radius of the turret ring. Two large diameters enclose ring gears (FF and RR, fig. 73). A keyway between the diameters locates a ring gear locking key (EE, fig. 73).

c. Planetary Gear Housing. The planetary gear housing (R, fig. 71) is mounted over the two ring gears in the main housing over a gasket (Q, fig. 71). The housings are bolted together by 10 socket head cap

screws (H, fig. 72). Locating diameters enclose the ring gears and two internal gears (CC and PP, fig. 73). A bearing diameter in the main drive shafts (GG and SS, fig. 73) and bearing diameters located in the planetary gear housing support the internal gear assemblies. The closed surface of the housing contains four bearing-retaining diameters for gear assemblies (AA, BB, LL, and MM, fig. 73). A machined angle pad at K, figure 72, with four $\frac{5}{16}$ -18NC-3 tapped holes, provides a mounting surface for the idler gear housing (L, fig. 71) over the spacing shim (K, fig. 72). Two dowel locating holes are machined on the closed surface of the planetary housing.

d. Motor Support Housing. The motor support housing (T, fig. 71) fits over gasket (S, fig. 71) on two dowel pins inserted in the planetary housing. The housing encloses the gear assemblies (BB, JJ with LL, and MM, fig. 73). It also supports the splined output gear (AA, fig. 73) of the differential. Seven socket head cap screws (J, fig. 72) secure the motor support housing to the planetary housing from the planetary casting flanged surface. The closed surface of the motor support housing has two dowel locating diameters, two bearing retaining diameters for gears (BB and MM, fig. 73), and a large casting boss with a locating diameter to support the hydraulic motor adapter housing (CC, fig. 71). Two $\frac{5}{16}$ -18NC-2 x 2 socket head cap screws and two $\frac{5}{16}$ -18NC-2 x $2\frac{1}{2}$ socket head cap screws secure the motor support to the planetary housing. The motor support housing may have a plug (Z, fig. 71). This plug has no function other than to seal the $\frac{7}{16}$ -20NC-3 tapped hydraulic port utilized on an earlier design.

e. Idler Gear Housing. (L, fig. 71.) This is the basic housing of the hand drive assembly and mounts over gasket (U, fig. 71) on two dowel pins assembled to the motor support housing. A machined angle pad at shim (K, fig. 72) (*c*, above) joins the planetary gear housing. Four socket head cap screws (N, fig. 72) secure the housings over spacing shim (K, fig. 72). Enclosed in the housing is a slip clutch assembly (M, N, P, Q, and R, fig. 73). It is secured in a sleeve inside the housing with four $\frac{1}{4}$ -20NC-2 x $\frac{3}{4}$ machine screws. The clutch bevel gear (M, fig. 73) secures to female clutch housing (N, fig. 72) with three No. 10-32 x $\frac{7}{8}$ socket head cap screws and a dowel pin. An inspection plate cover (M, fig. 72) held with four socket head cap screws (L, fig. 72) may be removed to adjust the tension of spring (Q, fig. 73) with nut (P, fig. 73). A machined surface and a locating diameter at no-back lock shim (K, fig. 71) provides a mounting surface for the no-back lock housing (J, fig. 71). Two machined bearing diameters position the single and double idler gears (T and U, fig. 73). Manual drive gear (S, fig. 73) is splined to join the clutch assembly

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at male clutch shaft (R, fig. 73), and is supported on a bearing which seats in the sleeve of the clutch assembly.

f. Idler Gear Housing Cover (W, fig. 71). This housing mounts to the idler gear housing (L, fig. 71) over gasket (V, fig. 71) to two dowels assembled to the idler gear housing. Two socket head cap screws (W, fig. 72) and five socket head cap screws (X, fig. 72) fasten the idler gear housing cover to the motor support housing (T, fig. 71) through drill holes in the idler gear housing (L, fig. 71). Three socket head cap screws (U, fig. 72) secure the idler gear housing cover to the idler gear housing. A large bearing diameter locates and encloses the differential (V, fig. 73) directly beneath the differential-shifting piston housing (X, fig. 71). Three identical-size bearing diameters locate the upper bearings of the enclosed single idler gear (U, fig. 73), the double idler gear (T, fig. 73), and the manual drive gear (S, fig. 73). A hex nut and lock washer secure the manual drive gear over its supporting bearing beneath bearing cover cap (DD, fig. 71). Retaining rings assemble in three identical-size grooves to retain the bearings and the disk covers which shield the bearings. Three tapped holes in the idler gear housing cover are employed to secure the bearing cover cap (DD, fig. 71) over manual drive gear (S, fig. 73) with three socket head cap screws (V, fig. 72). Four machined bosses tapped with $\frac{3}{8}$ -16NF-3 thread, provide a mounting location for the bracket supporting the hand-operated elevating pump and gunner's control.

g. Differential-Shifting Piston Housing (X, fig. 71). This housing assembles over a diameter concentric with the differential cage gear (V, fig. 73) and is fastened to the idler gear housing cover with five socket head cap screws (Y, fig. 72). The housing encloses a differential-shifting piston (UU, fig. 73) which connects to the differential shift-shaft gear (W, fig. 73) through a bearing mounted in the piston. A $\frac{7}{16}$ -20NF-3 tapped port in the piston housing (X, fig. 71) permits hydraulic fluid to enter the sealed pressure area of the piston housing from the gear pump in the hydraulic system. A manual return spring (WW, fig. 73) located over the piston is secured by the power-traversing-bypass-valve housing (h, below). Hydraulic piston seal (VV, fig. 73) seals hydraulic fluid within the working pressure area of the piston housing. A similar hydraulic piston seal in an undercut diameter of the piston housing holds hydraulic fluid within the working pressure area of the piston housing from below.

h. Power-Traversing-Bypass Valve. The power-traversing-bypass valve (Y, fig. 71) is secured to the differential-shifting piston housing (X, fig. 71) with five socket head cap screws (Z, fig. 72). The power-traversing-bypass-valve housing encloses a two-land valve-

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spool, sealed at both ends by hydraulic packing seals. The spool is mechanically operated in a chamber which is internally ported to join two channels running through the power-traversing-bypass-valve housing. Both channels are tapped at each end with $\frac{9}{16}$ -18NF-3 thread for fitting connectors to the hydraulic lines running from the two-way variable displacement pump, through the power-traversing-bypass valve to the hydraulic traversing motor (fig. 76).

i. *Lower Adapter Housing.* The lower adapter housing (CC, fig. 71) is mounted to a locating diameter of the motor support housing (T, fig. 71) and is fastened by four $\frac{5}{16}$ -18NC-2 socket head cap screws. A clearance diameter allows motor driven gear (YY, fig. 73) and its splined mounting shaft to enter the motor support housing and engage an internal spline of motor drive drum gear (JJ, fig. 73).

j. *Upper Adapter Housing.* The upper adapter housing (AA, fig. 71) mounts over dowels assembled to the lower adapter housing and is secured with six socket head cap screws (three $\frac{1}{4}$ -28NF-3 x $\frac{3}{4}$ and three $\frac{1}{4}$ -28NF-3 x $1\frac{1}{4}$). A bearing diameter secures motor driven gear (YY, fig. 73) in position on the splined shaft. Four $\frac{1}{4}$ -20NC-3 tapped holes and a large locating diameter are used to secure the hydraulic traverse motor (fig. 73) in position on the upper adapter housing (AA, fig. 71). Motor drive gear (BB, fig. 71) is keyed to the hydraulic traverse motor shaft and meshes with the motor driven gear (EE, fig. 71).

k. *No-Back Lock Housing* (J, fig. 71). This housing is piloted to a locating diameter in the idler gear housing (L, fig. 71). No-back lock shims (K, fig. 71) as required, are placed between the housings. A packing ring assembled in a groove at the no-back lock housing's pilot diameter provides a seal between the housings. Four socket head cap screws (P, fig. 72) secure the no-back lock housing to the idler gear housing. A bearing diameter supports the bearing of no-back lock bevel gear (L, fig. 73) in the housing. The bevel gear is keyed to the no-back driven bearing (K, fig. 73) located in a large diameter with no-back lock spring (J, fig. 73), no-back lock bar (H, fig. 73), and no-back drive bearing (G, fig. 73). A no-back lock ring (fig. 74) is concentrically assembled to enclose the no-back lock spring (fig. 74) and no-back lock bar (fig. 74). The lock ring is held in position in a groove in the no-back lock housing by the ring-locking pin shown in figure 74. Functional and safety features of the no-back lock are necessary for proper operation of the hand drive and turret-traversing mechanism.

l. *Bevel Gear Housing* (G, fig. 71). The bevel gear housing fastens to the no-back lock housing (J, fig. 71) over a gasket (H, fig. 71). A pilot diameter enters the diameter of the no-back lock housing.

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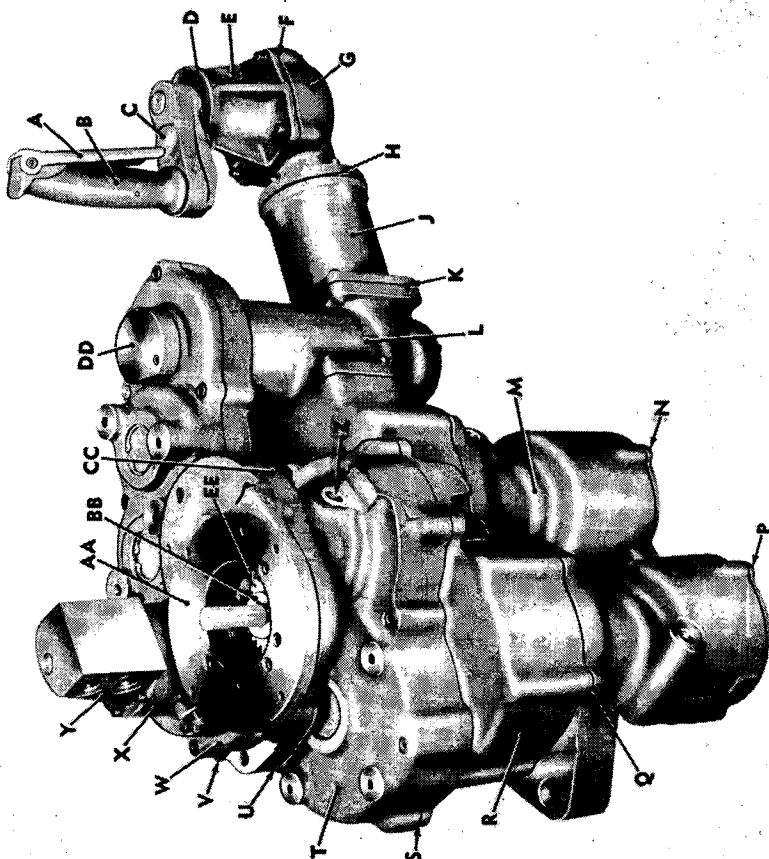
The bevel gear housing is secured with four socket head cap screws (Q, fig. 72) to the no-back lock housing. A bearing diameter retains the hand drive bevel gear (F, fig. 73) in the bevel gear housing. The bevel gear's keyed shaft enters the keyway of no-back lock drive bearing (G, fig. 73). A large pilot diameter positions the hand crank housing (E, fig. 71).

m. Hand crank housing (E, fig. 71). The hand crank housing assembles over bevel gear shims (F, fig. 71) to the bevel gear housing and is secured with four socket head cap screws (R, fig. 72). The number of shims used vary as required to properly mesh bevel gears (E and F, fig. 73). Two machined bearing locating diameters support the hand crank bevel gear (E, fig. 73) within the housing. The housing has a machined safety lock keyway (S, fig. 72).

n. Traversing Crank Arm (C, fig. 71). The crank arm is keyed to the shaft of hand crank bevel gear (E, fig. 73) and held in position on the shaft by a retaining ring above and below the undercut grooves on the shaft. A keyway encloses a hinged lock arm lever (D, fig. 71). A spring and spring follower assemble in the traversing crank arm beneath the lock arm lever. A sleeve is doweled to the traversing crank arm by hand crank assembly pin (T, fig. 72). A push-rod assembles loosely in the sleeve making contact with the lock arm lever (D, fig. 71) (*o* below).

o. Traversing Crank Handle (B, fig. 71). The crank handle assembles with a washer over the sleeve and is held in position by a pin staked in the handle. The pin enters and rides in an undercut diameter on the sleeve to permit handle rotation. A hinged cam in the handle engages the push-rod (*n* above) and the grip handle lever (A, fig. 71). The grip lever is hinged to the handle by a No. 10-24NF-8 x 11/8 brass screw, secured by a No. 10-24NF-3 3/8 x 1/8 hex nut.

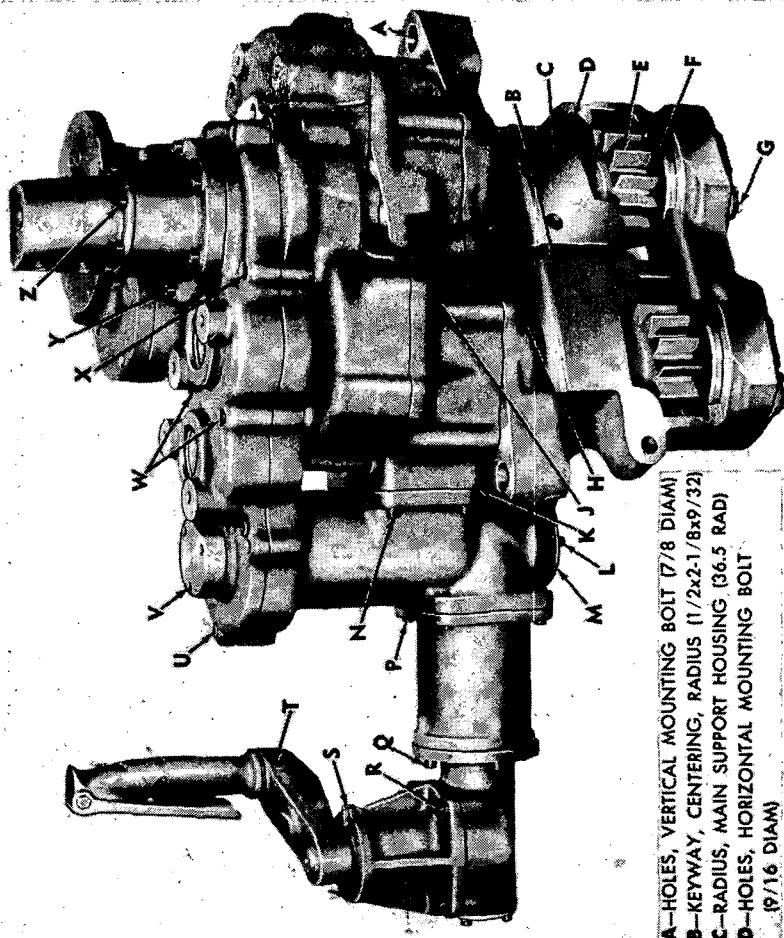
p. Spherical Bearing Housings. Two spherical bearing housings (N and P, fig. 71) mount in the main support housing (M, fig. 71). Each is secured by three socket head cap screws (G, fig. 72) to the main support housing. Contained in each housing is a spherical type bearing held by a retaining ring in an undercut diameter. A spherical bearing seal (F, fig. 72) circles the main drive shafts (GG and SS, fig. 73) below the traversing pinion gears (HH and TT, fig. 73) (*b* above). A spacer washer on each main shaft rests against the traversing pinion gear through the spherical bearing seal, to the inner race of the spherical bearing. A 1.563-18NEF x 7/16 nut over a keyed lock washer secures the bearing to the threaded end of the main shaft. The nut, lock washer, and spherical bearing housing is protected by a cover plate over a gasket. The cover plate is fastened to the spherical bearing housing with six No. 10-32NF-3 x 1/2 socket head cap screws.



- A—LEVER, GRIP HANDLE—7382939
 B—HANDLE, TRAVERSING CRANK—7382943
 C—ARM, TRAVERSING CRANK—7382940
 D—LEVER, LOCK ARM—7382930
 E—HOUSING, HAND CRANK—7382942
 F—SHIM, BEVEL GEAR—7382934
 G—HOUSING, BEVEL GEAR—7382944
 H—GASKET, NO-BACK LOCK—7382935
 I—HOUSING, NO-BACK LOCK—7382621
 J—SHIM, NO-BACK LOCK—7383378
 K—HOUSING, IDLER GEAR—7354190
 L—HOUSING, SUPPORT, MAIN—7353425
 M—HOUSING, SPHERICAL BEARING—7353591
 N—HOUSING, SPHERICAL BEARING—7353591
 O—GASKET, PLANETARY GEAR HOUSING—7382977
 P—GASKET, PLANETARY GEAR—7353384
 Q—GASKET, MOTOR SUPPORT HOUSING—7354208
 R—HOUSING, MOTOR SUPPORT—7978711
 S—GASKET, IDLER GEAR HOUSING—7354207
 T—GASKET, IDLER GEAR HOUSING COVER—7354209
 U—COVER, IDLER GEAR HOUSING—7353382
 V—HOUSING, DIFFERENTIAL-SHIFTING PISTON—7357316
 W—VALVE, POWER-BYPASS, ASSY—7357589
 X—PLUG, MOTOR SUPPORT HOUSING, 7/16-20NC-3x3/8
 Y—HOUSING, UPPER ADAPTER—7354205
 AA—GEAR, DRIVE, MOTOR—7387742
 BB—GEAR, LOWER ADAPTER—7978710
 CC—HOUSING, LOWER ADAPTER—7387185
 DD—CAP, BEARING COVER—7387185
 EE—GEAR, DRIVEN, MOTOR—7387744

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Figure 71. Traversing mechanism, hand drive, and shifting mechanism—7359006—front view.



- E—GEAR, TRAVERSING PINION—7380159
 F—SEAL, SPHERICAL BEARING—7382058
 G—SCREW, CAP, SOC-HD, 5/16-18NC-3x3/4—426367
 H—SCREW, CAP, SOC-HD, 5/16-18NC-3x7/8—217908
 J—SCREW, CAP, SOC-HD, 5/16-18NC-2x3/4—426367
 K—SHIM, IDLER GEAR HOUSING—7382831
 L—SCREW, CAP, SOC-HD, NO 10-32NF-3x5/8—217921
 M—COVER, LOWER INSPECTION PLATE—7387389
 N—SCREW, CAP, SOC-HD, 1/4-20NC-3x1—138202
 P—SCREW, CAP, SOC-HD, 1/4-20NC-2x7/8—217904
 Q—SCREW, CAP, SOC-HD, 1/4-20NC-2x7/8—217904
 R—SCREW, CAP, SOC-HD, 1/4-20NC-2x7/8—217904
 S—KEYWAY, SAFETY LOCK (5/16x45°)
 T—PIN, HAND CRANK—505546
 U—SCREW, CAP, SOC-HD, 5/16-18NC-2x5/8—217907
 V—SCREW, CAP, SOC-HD, NO 10-32NF-3x3/4—147118
 W—SCREW, CAP, SOC-HD, 5/16-18NC-2x2-1/2—138228
 X—SCREW, CAP, SOC-HD, 5/16-18NC-2x2—138226
 Y—SCREW, CAP, SOC-HD, 1/4-28NF-3x7/8—192284
 Z—SCREW, CAP, SOC-HD, NO 10-32NF-2x1/2—586425

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Figure 72. Traversing mechanism, hand drive, and shifting mechanism—7359006—rear view.

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Section II. PRINCIPLES OF OPERATION

36. General

a. In tracing the power paths through the traversing mechanism, hand drive, and shifting mechanism both in manual and in power operation, clockwise and counterclockwise, the manner in which the mechanism functions to traverse the turret will be described.

b. The sequence of shifting to or from either method of traversing will be followed. How the various subassemblies function to safeguard the equipment and operator will be explained individually.

Note. All motion will be described as taking place when viewed from the top or a normal turret-installed position.

37. Manual Drive Power Path—Clockwise

a. Grip handle lever (A, fig. 73) hinged to traversing crank handle (B, fig. 73) releases lock arm lever (D, fig. 73) from a safety lock keyway (S, fig. 72) at the hand crank housing by moving a cam against a push-rod in the handle against a spring in crank arm (C, fig. 73). The crank arm is turned clockwise. When the grip handle lever (A, fig. 73) is released, the spring in the hand crank arm returns the lock arm lever to the safety lock keyway position.

b. Hand crank bevel gear (E, fig. 73) keyed to the hand crank arm is rotated clockwise.

c. Hand drive bevel gear (F, fig. 73) in bevel gear housing (G, fig. 71) is driven to the right or clockwise by clockwise rotation of hand crank bevel gear (E, fig. 73).

d. No-back lock drive bearing (G, fig. 73) is driven to the right or clockwise by the keyed shaft of the hand drive bevel gear (F, fig. 73).

e. No-back lock bar (H, fig. 73) with no-back lock spring (J, fig. 73) within no-back lock ring (fig. 74) is driven to the right or clockwise. Refer to paragraph 46.

f. No-back bevel gear (L, fig. 73) keyed to the no-back driven bearing (K, fig. 73) is driven to the right or clockwise.

g. Clutch bevel gear (M, fig. 73) is driven counterclockwise by clockwise motion of no-back bevel gear (L, fig. 73).

h. Manual drive gear (S, fig. 73) is driven counterclockwise by counterclockwise rotation of clutch bevel gear (M, fig. 73) through a slip clutch assembly (R and N, fig. 73). Refer to paragraph 47.

i. Double idler gear (T, fig. 73) is revolved clockwise by counterclockwise rotation of the manual drive gear (S, fig. 73).

j. Single idler gear (U, fig. 73) is driven counterclockwise by clockwise rotation of the top gear of the double idler gear (T, fig. 73).

k. The differential shifting mechanism in the differential cage gear (V, fig. 73) is driven clockwise with the cage gear by counterclockwise rotation of the single idler gear (U, fig. 73). Differential shift-shaft gear (W, fig. 73) is "down" in mesh with differential single planet gears (X, fig. 73).

l. The differential double and splined output gears (Z and AA, fig. 73) revolve clockwise with the clockwise rotating differential cage gear (V, fig. 73).

m. Differential shift-shaft gear (W, fig. 73), single differential planet gears (X, fig. 73), and double differential planet gears (Y, fig. 73) do not rotate on their axis but revolve as a unit with the differential cage gear (V, fig. 73). Refer to paragraph 48.

n. Right drive gear (BB, fig. 73) in motor support housing (T, fig. 71) is driven counterclockwise by clockwise rotation of the differential double output gear (Z, fig. 73). Differential splined output gear (AA, fig. 73) is rotating clockwise in mesh with counterclockwise rotating left drive gear (MM, fig. 73). Refer to paragraph 38.

o. The internal planetary drive gear (CC, fig. 73) is driven counterclockwise by counterclockwise motion of right drive gear (BB, fig. 73).

p. Three planet drive gears (DD, fig. 73) held in position in the carrier of the main drive shaft (GG, fig. 73), are driven clockwise by the internal planetary drive gear (CC, fig. 73) which is rotating counterclockwise.

q. Main drive shaft (GG, fig. 73) rotates counterclockwise driven by the clockwise rotating planet drive gears (DD, fig. 73), moving counterclockwise as they drive against the stationary planetary ring gear (FF, fig. 73). Ring-gear lock key (EE, fig. 73) prevents the planetary ring-gear from being rotated by the planet drive gears (DD, fig. 73).

r. Traverse pinion gear (HH, fig. 73) splined to the main drive shaft (GG, fig. 73), rotates counterclockwise against a stationary turret ring-gear (AC, fig. 73). The turret ring-gear is bolted to the tank's hull. The traverse pinion gears (HH and TT, fig. 73) propel the tank's turret in a clockwise direction.

38. Antilash Power Path—Clockwise or Counterclockwise

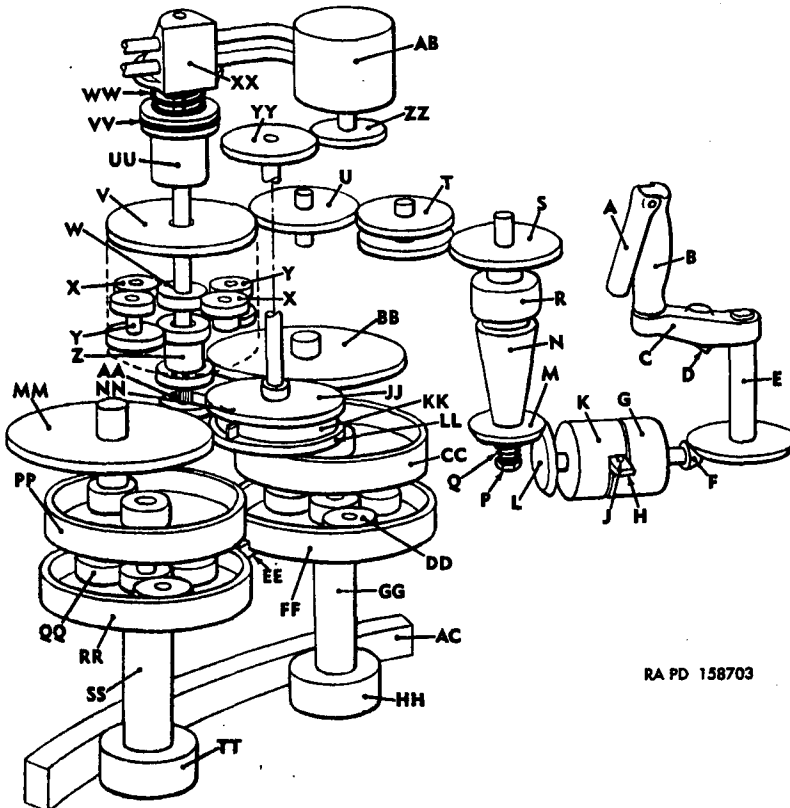
a. The motor drive drum gear (JJ, fig. 73) is driven clockwise by right drive gear (BB, fig. 73) rotating counterclockwise (par. 37n).

b. Lower backlash gear (LL, fig. 73) is driven clockwise by the motor drive drum gear (JJ, fig. 73) through backlash gear spring (KK, fig. 73) (par. 49).

A—LEVER, GRIP HANDLE—7382939
 B—HANDLE, TRAVERSING CRANK—7382943
 C—ARM, TRAVERSING CRANK—7382940
 D—LEVER, LOCK ARM—7382930
 E—GEAR, BEVEL, HAND CRANK—7382910
 F—GEAR, BEVEL, HAND DRIVE—7388645
 G—BEARING, DRIVE
 H—BAR, LOCK
 J—SPRING, LOCK
 K—BEARING, DRIVEN
 L—GEAR, BEVEL, NO-BACK—7382700
 M—GEAR, BEVEL, CLUTCH—7353361
 N—HOUSING, FEMALE CLUTCH—7353360
 P—NUT, ADJUSTABLE, CLUTCH—426754
 Q—SPRING, SLIP CLUTCH—7387443
 R—SHAFT, MALE CLUTCH—7353364
 S—GEAR, MANUAL DRIVE—7353359
 T—GEAR, DOUBLE IDLER—7382656
 U—GEAR, SINGLE IDLER—7382651
 V—GEAR, CAGE, DIFFERENTIAL—7353311
 W—GEAR, SHIFT-SHAFT, DIFFERENTIAL—7353389
 X—GEAR, SINGLE PLANET, DIFFERENTIAL—7353279
 Y—GEAR, DOUBLE PLANET, DIFFERENTIAL—7353302
 Z—GEAR DOUBLE OUTPUT, DIFFERENTIAL—7353355

LOCK, NO-BACK—
 7382619

AA—GEAR, SPLINED, OUTPUT, DIFFERENTIAL—
 7353365
 BB—GEAR, DRIVE, RIGHT—7353309
 CC—GEAR, INTERNAL, PLANETARY DRIVE—7353308
 DD—GEAR, PLANET DRIVE—7380150
 EE—KEY, PLANETARY RING GEAR—7353306
 FF—GEAR, RING, PLANETARY—7353424
 GG—SHAFT, DRIVE, MAIN—7353307
 HH—GEAR, TRAVERSING PINION—7380159
 JJ—GEAR, DRUM, MOTOR DRIVE—7387743
 KK—SPRING, BACKLASH, GEAR—7355995
 LL—GEAR, BACKLASH, LOWER—7357598
 MM—GEAR, DRIVE, LEFT—7353300
 NN—PIN, MOTOR DRIVE DRUM GEAR—7357595
 PP—GEAR, INTERNAL, PLANETARY DRIVE—7353308
 QQ—GEAR, PLANET DRIVE—7380150
 RR—GEAR, RING, PLANETARY—7353424
 SS—SHAFT, DRIVE, MAIN—7353307
 TT—GEAR, TRAVERSING PINION—7380159
 UU—PISTON, SHIFTING, DIFFERENTIAL—7357315
 VV—SEAL, HYDRAULIC PISTON—546803
 WW—SPRING, MANUAL RETURN, PISTON—
 7357313
 XX—VALVE, POWER-BYPASS, ASSY—7357589
 YY—GEAR, DRIVEN, MOTOR—7387744
 ZZ—GEAR, DRIVE, MOTOR—7387742
 AB—MOTOR, HYDRAULIC, ASSY—7353164
 AC—GEAR, RING, TURRET



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Figure 73. Traversing mechanism, hand drive, and shifting mechanism
 7359006—schematic.

c. Left drive gear (MM, fig. 73) rotates counterclockwise driven by lower backlash gear (LL, fig. 73). Refer to paragraph 37a. The backlash gear spring (KK, fig. 73) is wound counterclockwise to a predetermined torque value (par. 49) and exerts a clockwise torque on left drive gear (MM, fig. 73). Refer to figure 75.

d. An identical system of gears; internal planetary drive gear (PP, fig. 73), three planet drive gears (QQ, fig. 73), planetary ring gear (RR, fig. 73) drives the main drive shaft (SS, fig. 73) with the traverse pinion gear (TT, fig. 73) counterclockwise against the stationary turret ring-gear.

e. The clockwise torque exerted by the backlash gear spring (KK, fig. 73) acting against the left drive gear (MM, fig. 73) is transmitted and amplified through the planetary gear reduction assembly to impart a clockwise torque on counterclockwise rotating traverse pinion gear (TT, fig. 73). Refer to paragraphs 40 and 49 (fig. 75).

39. Manual Drive Power Path—Counterclockwise

a. Counterclockwise operation of the manual traverse crank handle (B, fig. 73) reverses the direction of rotation of all gears and shafts indicated in paragraph 37.

b. The traverse pinion gears (HH and TT, fig. 73) now rotate clockwise on the main drive shafts (GG and SS, fig. 73) against the turret ring-gear. The turret is now driven in a counterclockwise direction.

c. During manual traverse counterclockwise operation, the antilash action of the backlash gear spring (KK, fig. 73) is similar to the action indicated in paragraph 38 above. Refer to paragraph 40 (fig. 75).

d. The traverse pinion gear (TT, fig. 73) is driving the turret counterclockwise from the differential splined output gear (AA, fig. 73).

e. Traverse pinion gear (HH, fig. 73) attached to the main drive shaft (GG, fig. 73) is applying the antilash torque of lower backlash gear spring (KK, fig. 73) through the motor drive drum gear (JJ, fig. 73) meshing with right drive gear (BB, fig. 73). Refer to paragraph 49.

40. Summary Manual Drive Operation

a. Clockwise or counterclockwise motion of the traverse crank handle (B, fig. 73) traverse the turret in a clockwise or counterclockwise direction through the traverse pinion gear which is leading in the direction of turret rotation.

b. Antilash action applying 150 to 175 lb-ft of "toe-in" torque is maintained by the traverse pinion gear (TT, fig. 73) during clockwise turret rotation. During counterclockwise rotation, the traverse pinion gear (HH, fig. 73) is applying 150 to 170 lb-ft "toe-in" torque against the turret ring-gear.

c. During manual operation, clockwise or counterclockwise, the motor-drive drum gear (JJ, fig. 73) rotates the motor driven gear (YY, fig. 73) on a splined shaft joining both gears.

d. Motor driven gear rotates the motor drive gear (ZZ, fig. 73) keyed to the output shaft of the hydraulic traversing motor (fig. 73).

e. During manual operation, clockwise or counterclockwise, the hydraulic traversing motor rotates freely since no hydraulic pressure is being applied. Refer to paragraph 51.

41. Manual-to-Power Shifting

a. Manual traverse crank handle (B, fig. 73) is locked in position by lock arm lever (D, fig. 73) entering the safety slot of hand crank housing (E, fig. 71) upon release of grip handle lever (A, fig. 71).

b. A micro switch mounted on a bracket is fastened to the hand crank housing (E, fig. 71) in a position to be actuated by the lock arm lever (D, fig. 71) at the safety lock keyway (S, fig. 72).

c. The dump valve in hydraulic system is actuated, allowing gear pump pressure to enter the differential-shifting piston housing (X, fig. 71) to lift the differential-shifting piston (UU, fig. 73) against a manual return spring (WW, fig. 73).

d. The differential shift-shaft gear (W, fig. 73) attached to the differential-shifting piston is drawn from mesh with both single planet gears (X, fig. 73) in the differential cage gear (V, fig. 73), thereby disconnecting the hand drive gear system from the traversing mechanism.

e. As the differential shifting piston (UU, fig. 73) rises it compresses spring (WW, fig. 73) and contacts a pin from the power-bypass-valve assembly (XX, fig. 73). Refer to paragraph 51 (fig. 76).

f. The position of the power-bypass-valve allows hydraulic pressure to operate the hydraulic traverse motor (fig. 73).

42. Power Operation—Clockwise and Counterclockwise

Note. The direction the hydraulic motor rotates is indicated by the direction in which its output shaft revolves when viewed from the shaft's end.

a. Power Operation—Clockwise.

- (1) The motor driven gear (YY, fig. 73) is driven clockwise by the clockwise rotation of motor drive gear (ZZ, fig. 71) keyed

to the hydraulic traverse motor output shaft. Refer to note above.

- (2) The motor drive drum gear (JJ, fig. 73) is driven clockwise by clockwise rotation of motor driven gear (YY, fig. 73) on a shaft common to both gears.
- (3) Right drive gear (BB, fig. 73) is driven counterclockwise by clockwise rotation of motor drive drum gear (JJ, fig. 73).
- (4) Internal planetary drive gear (CC, fig. 73) is driven counterclockwise by right drive gear (BB, fig. 73) rotating counterclockwise.
- (5) Three planet drive gears (DD, fig. 73) are driven clockwise by counterclockwise rotation of internal planetary gear (CC, fig. 73).
- (6) The traverse pinion gear (HH, fig. 73) is driven counterclockwise by the three planet gears (DD, fig. 73) which rotate clockwise and drive the main shaft assembly counterclockwise about planetary ring gear (FF, fig. 73).
- (7) The turret is driven clockwise by the counterclockwise rotation of the traverse pinion gear (HH, fig. 73) against the large turret ring-gear (AC, fig. 73). Refer to paragraph 43.

b. Power Operation—Counterclockwise.

- (1) Counterclockwise rotation of the hydraulic traverse motor drives motor driven gear (YY, fig. 73) in the same manner but in the opposite direction (*a* above).
- (2) The turret is driven counterclockwise by the clockwise rotation of the traverse pinion gear (HH, fig. 73).
- (3) Displacing the gunner or commander power traverse controls to the right drives the turret through the hydraulic and traverse mechanism, clockwise or to the right.
- (4) Displacing the gunner or commander power traverse controls to the left drives the turret counterclockwise or to the left.

43. Antilash Power Path During Power Operation

a. The antilash power path to the traverse pinion gear (TT, fig. 73) from the lower backlash gear (LL, fig. 73) is the same as that during manual operation—clockwise (par. 38).

b. The antilash path during clockwise or counterclockwise power operation is through the planetary gear reduction system from the backlash gear spring (KK, fig. 73) to the traverse pinion gear (TT, fig. 73).

c. During power operation differential shift-shaft gear (W, fig. 73) is out of mesh with differential single planet gears (X, fig. 73) and

the differential cage gear (V, fig. 73) remains stationary held by the no-back lock. Refer to paragraph 46.

d. Differential shift-shaft gear (W, fig. 73) is rotating, driven by the differential splined output gear (AA, fig. 73) during power operation.

e. Differential shifting piston (UU, fig. 73) does not rotate. The differential shift-shaft (W, fig. 73) is connected to it through a bearing (par. 50).

f. The differential double output gear (Z, fig. 73) is driven by the right drive gear (BB, fig. 73) during power operation (par. 48).

44. Summary Power Operation

a. During power operation, the hand drive is disconnected from the traversing mechanism in the differential cage (V, fig. 73) of the shifting mechanism.

b. Power operation, clockwise and counterclockwise, is always from the hydraulic motor (AB, fig. 73) through the traverse pinion gear (HH, fig. 73) connected through the planetary gear reduction system to the motor drive drum gear (JJ, fig. 73).

c. The antilash path during power operation, clockwise and counterclockwise, is identical to the manual drive antilash action. Clockwise and counterclockwise antilash motion always travels to the traversing pinion gear (TT, fig. 73) from the lower backlash gear (LL, fig. 73) connected through a planetary gear system. Antilash torque is supplied by backlash spring (KK, fig. 73) connected between motor drive drum gear (JJ, fig. 73) and lower backlash gear (LL, fig. 73). Refer to paragraph 49.

d. During power operation differential shift-shaft gear (W, fig. 73) in the differential cage (V, fig. 73) is being rotated freely. Differential single planet gears (X, fig. 73) are rotating freely, driven by differential double planet gears (Y, fig. 73) and differential double output gear (Z, fig. 73).

45. Power-to-Manual Operation—Shifting

a. When the traversing grip handle lever (A, fig. 73) is compressed, cam and push-rod in traverse crank handle (B, fig. 73) actuates the lock arm lever (D, fig. 73) to disengage the micro switch located on the hand crank housing (E, fig. 71).

b. A dump valve connected to the differential-shifting piston housing is opened to permit hydraulic fluid to return to the hydraulic reservoir from the differential shifting piston (UU, fig. 73).

c. Reduced pressure beneath the piston allows a spring in the power-traversing-bypass valve to return the valve-spool to the manual position (fig. 76). Refer to paragraph 51.

d. Reduction or "dumping" of differential shifting piston pressure allows manual return spring (WW, fig. 73) to return differential shifting piston (UU, fig. 73) to the manual position meshing the differential shift-shaft gear (W, fig. 73) with both single planet gears (X, fig. 73). Refer to paragraph 50.

e. Manual operation is possible only from the gunner's position.

Warning: Since the commander override controls have precedence over the manual or power control of the gunner, damage or destruction to the differential shifting mechanism may result unless special operating precautions are observed by the gunner and commander (par. 48).

Warning: The gunner should always return the manual traversing handle to the power or safely lock position where the micro switch is located when the commander overrides his control.

Warning: The commander must never release his traversing override control while the turret is tracking or is traversing at "slew" or top speeds. Releasing the commander override control is permitted only after the turret is stationary or when it is positively known that the gunner's controls are in the power position.

46. No-Back Lock

a. The no-back lock functions as a safety device to protect the mechanism and the gunner. It holds the turret to any manually traversed position. The no-back lock action allows an applied torque to travel through the device from the input to the output-end only. Motion cannot be transmitted back from the no-back lock driven bearing (K, fig. 73) to the no-back lock drive bearing (G, fig. 73).

b. The no-back lock bar (H, fig. 73) is constructed so that it may be rotated within a no-back lock ring (fig. 74).

c. The lock ring is held by the locking ring pin (fig. 74). Rotation ceases when an attempt is made to rotate the lock bar in an off-center position. It will bind against the lock ring's inside diameter. Refer to lower cross-sectional view (fig. 74).

d. The no-back lock bar is constructed so that when driven from one surface by no-back lock drive bearing (G, fig. 73), it retains the proper location on-center within the held lock ring. If driven from the opposite surface by no-back lock driven bearing (K, fig. 73), the lock bar no longer retains its on-center position. A binding action occurs. No motion is possible (fig. 74).

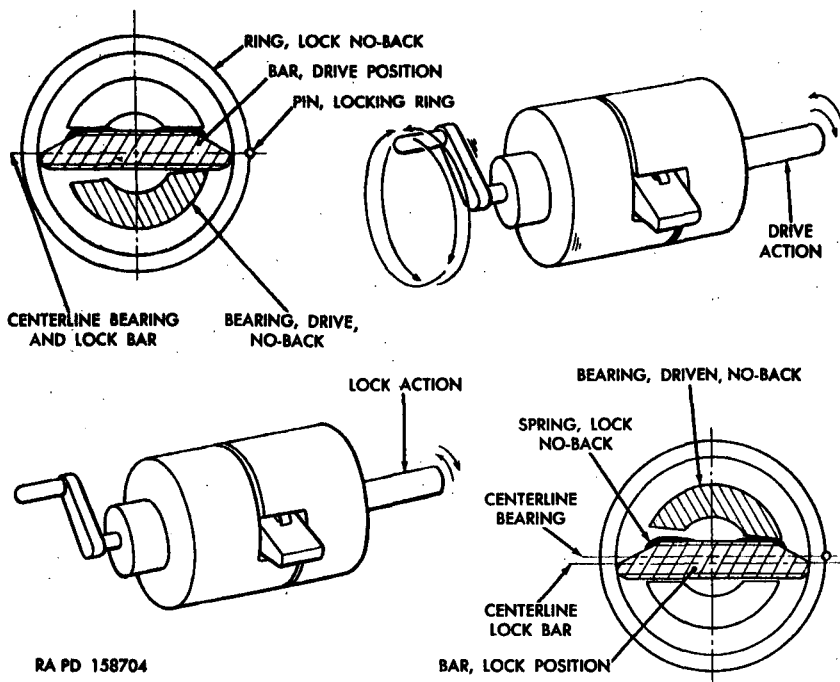


Figure 74. No-back lock and drive action.

48. Differential Shifting—Mechanism

a. In the differential, the shift-shaft gear (W, fig. 73) is splined and enters the splined output gear ($\Lambda\Lambda$, fig. 73) through differential double output gear (Z, fig. 73).

b. During manual operation the shift-shaft gear (W, fig. 73) meshes with two differential single planet gears (X, fig. 73). Each planet gear in turn meshes with two differential double planet gears (Y, fig. 73).

c. The differential double planet gear meshes with the differential double output gear (Z, fig. 73).

d. An opposing torque acting on differential shift-shaft gear (W, fig. 73) meshing with single planet gears (X, fig. 73) drives the differential output gears (Z and $\Lambda\Lambda$, fig. 73) as a unit.

e. Due to the non-concentric design, high planet gear speeds, and high torque values, together with the need for a positive shifting device, "timing" the single and double planet gears within the differential is extremely important.

- (1) At only two diametrically opposite positions of the differential double planet gears (Y, fig. 73) are the teeth of the

e. The side of the lock bar from which rotation is possible becomes the drive side. The side of the lock bar to which motion can be transmitted is the driven side.

f. The no-back lock spring (J, fig. 73) must be assembled between the no-back driven bearing (K, fig. 73) and the no-back lock bar (H, fig. 75). The spring normally maintains the lock bar in a position to bind readily against the lock ring. It attempts at all times to force the lock bar off-center away from the driven bearing (fig. 74).

g. Heavy no-back lock spring tension will increase the manual effort to traverse the turret by increasing the friction of the lock bar against the lock ring.

h. "Proper lock-action" is necessary to prevent the turret from drifting "off-target" when manual operation is employed.

i. The no-back lock also functions in conjunction with the slip clutch mechanism (par. 47) to protect the operator, the hand drive, and the traversing mechanism from damage should a heavy turret impact reflect power into the gear system from the traversing pinion gears (E, fig. 72).

j. Should the lock bar (H, fig. 73) and the no-back lock spring (J, fig. 73) be inverted within the no-back lock drive and driven bearings (G and K, fig. 73), rotation of the traverse crank handle is no longer possible.

47. Slip Clutch

a. The slip clutch protects the gear mechanism against torque overload damage during manual operation. It is primarily a male and female conic section loaded by an adjustable spring and set to slip when a torque value of 650 lb-in appears at the no-back lock bevel gear (L, fig. 73).

b. Clutch bevel gear (M, fig. 73) is fastened to the clutch housing (N, fig. 73). Male clutch shaft (R, fig. 73) extends through the clutch housing and clutch bevel gear (M, fig. 73). Slip clutch spring (Q, fig. 73) is compressed against clutch bevel gear (M, fig. 73) by an adjustable nut (P, fig. 73) on male clutch shaft (R, fig. 73) to hold the mating conic section at the required value (α above).

c. Shock action due to a ballistic impact or should the turret hit an object while in motion, is absorbed by the slip clutch. The male section of the clutch (R, fig. 73) can rotate with the traversing and hand drive gear system until the torque overload value is no longer great enough to cause internal damage.

smaller 16-tooth and larger 18-tooth gear on the common hub directly in alignment. At any other position, tooth to tooth displacement between each gear of the differential double planet gear is evident.

- (2) An "X" etched on the smaller of the double gear indicates the "in-line" positions of a tooth of each gear on the common hub (Y, fig. 73).
- (3) Mounted on pins in the differential cage (V, fig. 73) each of two identical planet gear systems consisting of single and double planet gears (X and Y, fig. 73) may be rotated independently when not meshed with either differential shift-shaft gear (W, fig. 73) or double output gear (Z, fig. 73).
- (4) Unless the "X" marks on both double planet gears (Y, fig. 73) are positioned "in time" (aligned 180° apart) relative to one another when meshed with double output gear (Z, fig. 73), the difference in tooth displacement between the two differential planet gear systems ((3) above) will prevent the shift-shaft gear (W, fig. 73) from meshing properly with the single planet gears (X, fig. 73).

f. Differential splined output gear (AA, fig. 73) meshes with left drive gear (MM, fig. 73). Differential double output gear (Z, fig. 73) meshes with right drive gear (BB, fig. 73).

g. The differential-shift mechanism isolates the hand drive from the traversing mechanism during motor drive operation.

- (1) The differential shift-shaft gear (W, fig. 73) is lifted by differential shifting piston (UU, fig. 13) (par. 50).
- (2) The no-back lock holds the differential cage gear (V, fig. 71) stationary. Refer to lock action in figure (74.)
- (3) Right drive gear (BB, fig. 73) drives differential double output gear (Z, fig. 73) which in turn drives single and double differential planet gears (X and Y, fig. 73).
- (4) Left drive gear (MM, fig. 73) drives differential splined output gear (AA, fig. 73) in an opposite direction from that of differential double output gear (Z, fig. 73).

h. Since the differential single planet gears (X, fig. 73) and the differential shift-shaft gear (W, fig. 73) are rotating at high speeds in opposite directions during power operation, any attempt to switch the mechanism suddenly to manual operation will result in extensive damage to the differential shifting mechanism. The high speed gears rotating in opposite directions will attempt to establish mesh necessary for manual operation.

Note. Refer to "WARNING" in paragraph 45.

49. Anti-Lash Mechanism

a. Motor drive drum gear (JJ, fig. 73) is connected to counterclockwise-wound backlash spring (KK, fig. 73) by backlash drum gear pin (NN, fig. 73). The spring exerts a counterclockwise torque against right drive gear (BB, fig. 73).

b. Lower back lash gear (LL, fig. 73) is connected to counterclockwise-wound backlash spring (KK, fig. 73) by a slot at the gear's hub (fig. 75). The spring attempting to uncoil exerts a clockwise torque on left drive gear (MM, fig. 73).

c. The torque exerted to "toe-in" the traverse pinion gears (fig. 75) is determined by the backlash spring (KK, fig. 73). 70 to 90 lb-in torque between drum gear (JJ, fig. 73) and backlash gear (LL, fig. 73) is wound into the backlash spring.

d. 150 to 170 lb-ft of torque is developed at the traverse pinion gears (HH and TT, fig. 73) against the turret ring gear (AC, fig. 73).

e. Both traversing pinion gears "toe-in" against the turret ring gear and maintain a constant value of antilash torque. Lash is eliminated between the traverse pinions and turret ring gear and between all meshing gears in the planetary gear reduction systems in the traversing mechanism.

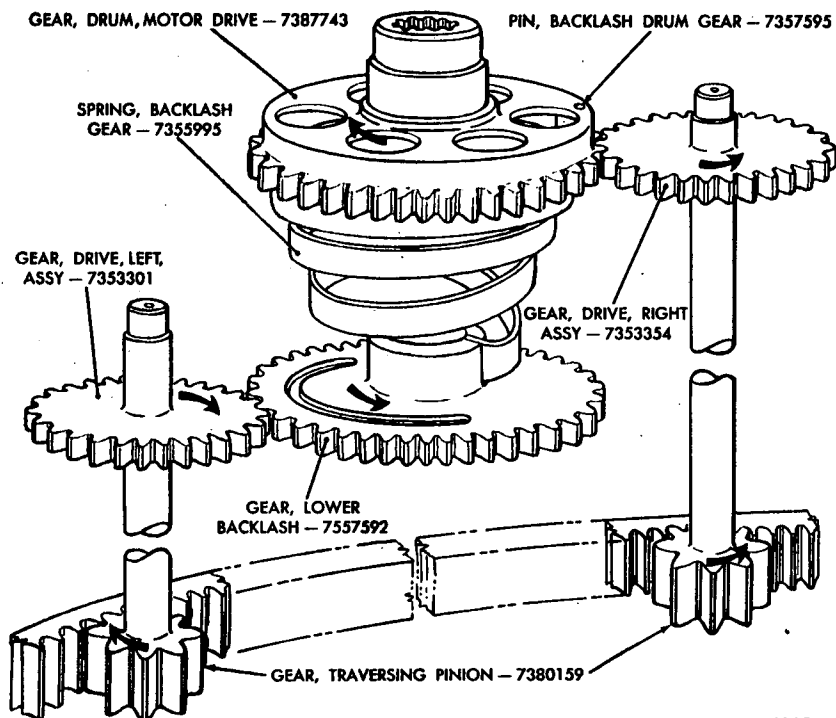
f. When the traverse pinion gears are disengaged from mesh with the turret ring gear by removal of the traverse mechanisms, complete unwind of backlash spring (KK, fig. 73) is prevented. The pin (NN, fig. 73) which enters the crescent-shaped slot on the inner face of the lower backlash gear (LL, fig. 73) prevents complete unwind of the spring (fig. 75).

50. Differential Shifting Piston Mechanism

a. Utilization of gear pump pressure by the piston shifting mechanism permits rapid positive shifting from manual to power operation. When power fails, the hand drive mechanically meshes the differential shift-shaft gear (W, fig. 73) with the differential single planet gears (X, fig. 73) to establish manual operation with a minimum loss in time and effort.

b. Gear pump hydraulic pressure enters a sealed working area of the differential shifting piston housing (X, fig. 71) and raises the piston (UU, fig. 73) against manual piston return spring (WW, fig. 73). Differential shift-shaft gear (W, fig. 73) is disengaged for power operation.

c. When the micro-switch at the gunner's hand is released by action of the grip handle lever (A, fig. 73) the dump-valve allows the piston



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Figure 75. Antilash action.

manual return spring (WW, fig. 73) to return the piston to manual position.

d. The piston action disconnects the hand drive before contacting the power-traversing-bypass-valve spool (fig. 76).

e. A minimum of 55 psi acting on a 2.2 sq in piston area against 115 psi manual return pressure is required to raise the piston. Operating pressure is the gear pump pressure of the hydraulic system.

51. Power-Traversing-Bypass Valve

a. When shifting to power operation after disconnecting the hand drive from the traversing mechanism, the piston as it continues to rise, contacts an extension of the power-bypass-valve spool (fig. 76). From the two-way variable displacement pump hydraulic pressure to drive the motor, must pass through one of the two ports of the power-bypass valve (XX, fig. 73) and returns to the pump through the other. Until the power-bypass-valve spool is lifted by the piston contacting the extension of the "spool" against a spring in the power-

bypass valve (fig. 76) any hydraulic pressure "bypasses" the hydraulic motor internally from the driving line to the return line.

b. After the differential shifting piston has lifted the power-bypass valve, closing the internal passage between the hydraulic drive lines, fluid must pass through the hydraulic motor, driving it in the desired direction and at the required rate of speed.

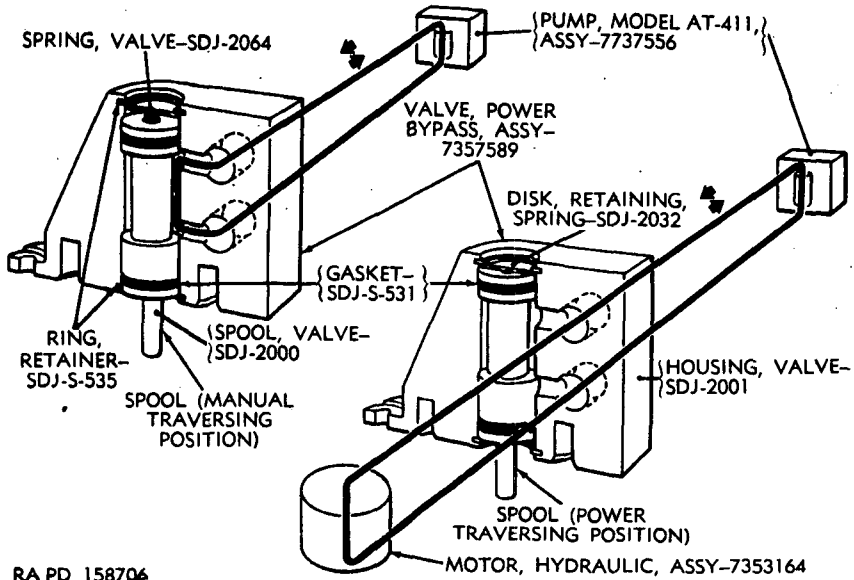


Figure 76. Power-traversing-bypass valve.

CHAPTER 6

MISCELLANEOUS COMPONENTS

52. Selector Valve

a. Construction. The selector valve is a two position boost-actuated spring return valve which is located at the junction of the power and manual gun-elevating and depressing oil lines (fig. 37). Two oil lines from the power pack oil reservoir, two oil lines from the hand-operated elevating pump, two oil lines to the gun-elevating cylinder, and an oil line from the power-pack supercharge gear pump are connected to the ports of the selector valve (fig. 37). The selector valve

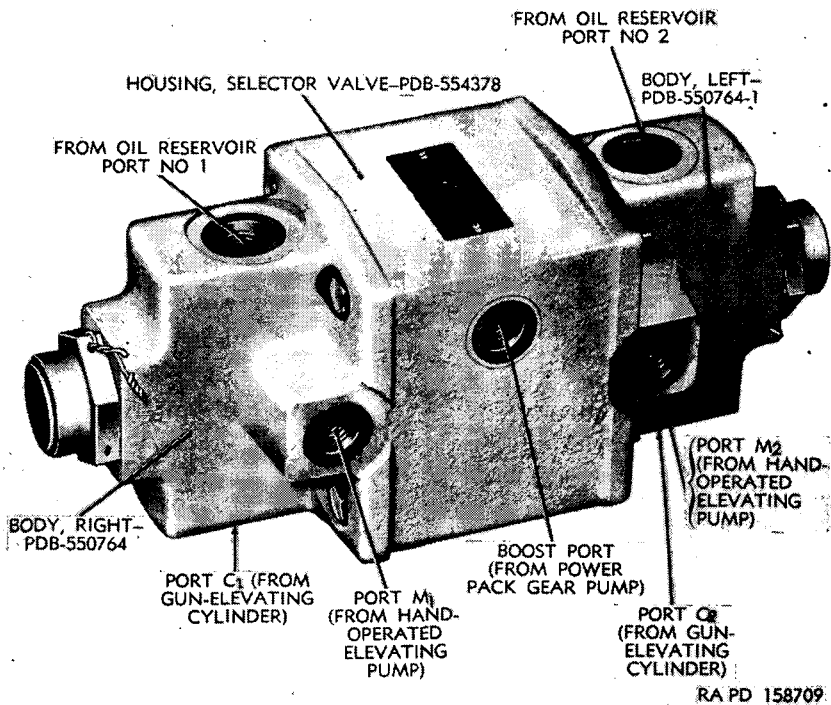


Figure 77. Selector valve.

(fig. 77) is composed of two identical bodies which contain identical sets of working parts. The bodies are attached to the selector valve housing which contains two identical pistons.

b. Principles of Operation. The selector valve shuts off the oil passages from the hand-operated elevating pump to the gun-elevating cylinder and opens the oil passages from the elevating hydraulic pump whenever the power-pack is in operation. It also acts to connect the oil line passages from the manual hydraulic system to the gun-elevating cylinder if the power pack fails or is shut off.

- (1) When the power pack is not in operation, the parts of the valve are in the position as shown in B of figure 79. Oil from the hand-operated elevating pump enters port M1, flows past the poppet, into the bore of the sleeve, through the opening near the lower end of the sleeve and out port C1 to the gun-elevating cylinder. Since the selector valve is symmetrical, port M2 in this position is connected to port C2. In the manual-hydraulic position (B of fig. 79), the sleeves block the flow of oil from oil reservoir port 1 to Port C, and oil reservoir port 2 to port C2; flow of pressure oil is from the hand-operated elevating pump through the selector valve to the gun-elevating cylinder and the flow of scavenge oil is from the opposite side of the elevating cylinder piston rod to the selector valve and back to the pump is a closed circuit (fig. 37).
- (2) When the power pack is in operation (A of fig. 79), oil from the power-pack supercharge gear pump enters the selector valve through the boost port and forces the pistons (fig. 78) outward (A of fig. 79). The poppet is forced into the sleeve by the piston until it is seated, closing off port M1 and the passage of oil from the hand-operated elevating pump. Further movement of the piston and poppet causes the sleeve to be displaced against the sleeve return spring, aligning the oil groove in the surface of the sleeve with oil reservoir port 1 and port C1 permitting the flow of oil from the elevating hydraulic pump to the gun elevating cylinder. Also in this position oil reservoir port 2 is connected to port C2; thus port M2 is closed. Therefore when the power pack is in operation the flow of pressure oil is from the elevating hydraulic pump through the selector valve to the gun-elevating cylinder and scavenger oil is from the opposite end of the cylinder through the other half of the selector valve to the pump and oil reservoir.

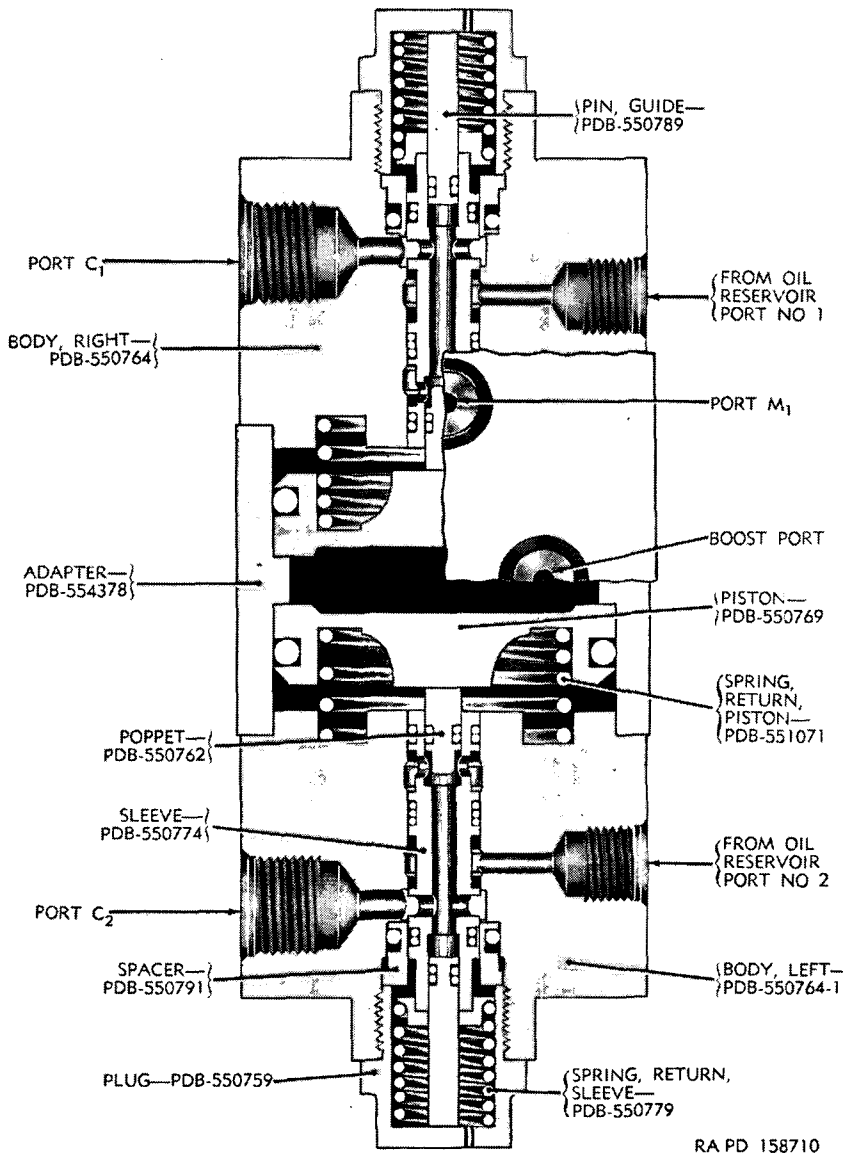
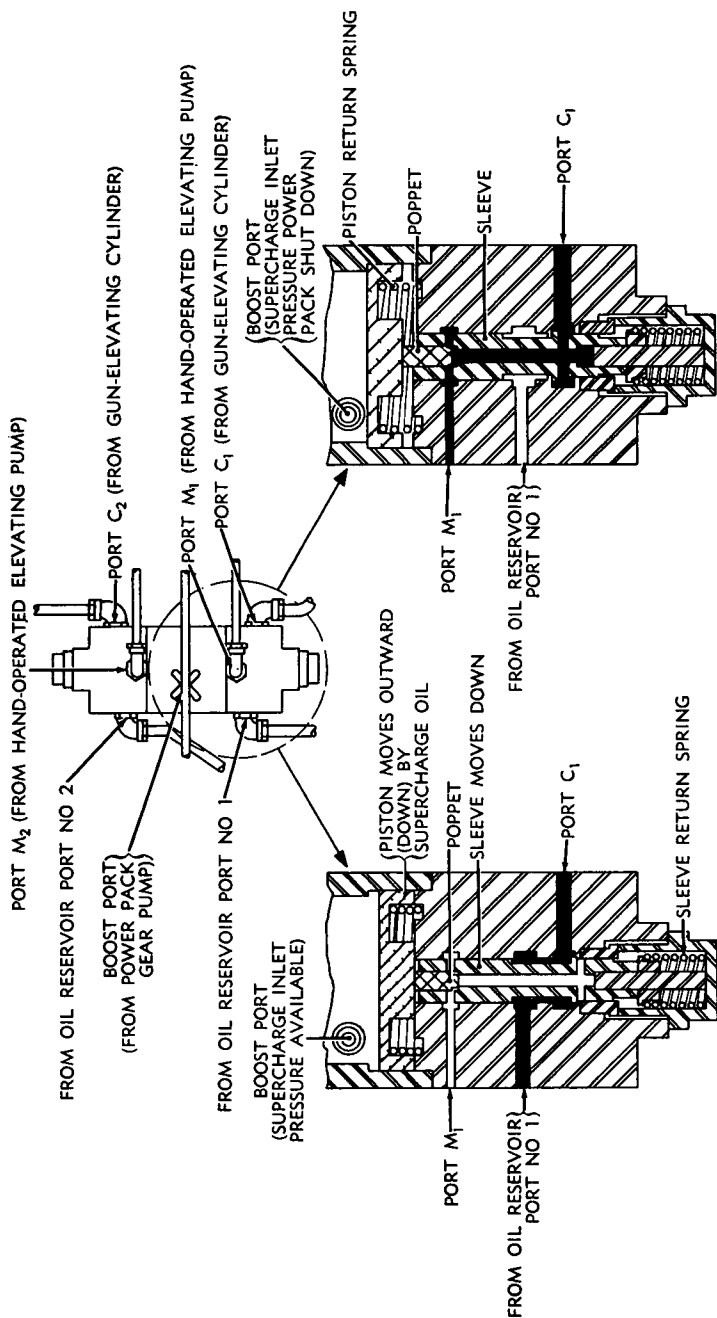


Figure 78. Selector valve—cross section.

- (3) When the oil pressure from the power-pack supercharge gear pump fails below 50 psi, the piston return springs move the pistons and sleeves to their original positions (fig. 78). Pressure from the manual-hydraulic gun-elevating system,



A
SCHEMATIC SECTION SHOWING ONE
HALF OF VALVE WHEN POWER PACK
IS IN OPERATION

SCHEMATIC SECTION SHOWING ONE HALF OF VALVE WHEN MANUAL-HYDRAULIC POWER IS IN OPERATION

Figure 79. Selector valve—operating positions.

acting under the shoulder of the poppet, forces the poppet up against the piston, thus enabling the gun-elevating system to be operated via man wall-hydraulic system.

- (4) In elevating the gun, oil under pressure from the elevating pump enters from oil reservoir port 2 (or port M2 in manual-hydraulic operation) and is discharged through port C2 to the elevating cylinder (figs. 37 and 81). Scavenge oil from the other side of the gun-elevating-cylinder piston is returned to port C1 of the selector valve and discharged to return to the elevating pump. Through the oil reservoir port 1 (or port M1 in manual-hydraulic operation). In depressing the gun, oil under pressure from the elevating pump enters from oil reservoir port 1 (or port M1 in manual-hydraulic operation) and is discharged through port C1 to the elevating cylinder (figs. 37 and 81). Scavenge oil from the other side of the gun-elevating-cylinder piston is returned to port C2 of the selector valve and discharged to return to the elevating pump through the oil reservoir port 2 (or port M2 in manual-hydraulic operation).

c. Data.

Make----- Pacific Division, Bendix Aviation Corp
Ordnance part number----- 7387750
Weight----- 10 lb
Length----- $8\frac{3}{4}$ in
Width (or depth)----- 3 in
Port data----- Refer to table IV for port data
Actuation data----- Refer to table V for valve actuation data

Table IV. Selector Valve Ports

Port	Tube size (in.)	Tap size	Port description	Port connects to—
Boost.....	1/4	1/16-20NF3	Supercharge pressure.	Oil reservoir port 12.
M1.....	1/4	1/16-20NF3	Manual-hydraulic elevating pressure.	Hand-Operated Elevating pump locking valve Port B.
C1.....	1/2	3/4-16NF3	Gun-elevating cylinder pressure.	Gun-elevating cylinder port in gimbal body.
Oil reservoir port 1.	3/8	1/16-18NF3	Power elevating pressure.	Oil reservoir port 1.
M2.....	1/4	1/16-20NF3	Manual-hydraulic elevating pressure.	Hand-operated elevating pump locking valve Port D.
C2.....	1/2	3/4-16NF3	Gun-elevating-cylinder pressure.	Gun elevating cylinder port in gimbal plate.
Oil reservoir.....	3/8	1/16-18NF3	Power elevating pressure.	Oil reservoir port 1.

Table V. Selector Valve Actuation

Boost port	Pressure	Actuation
0 psi.....	{ 750 psi at Port M1..... 750 psi at Port M2.....	Port C1 fully open. Port C2 fully open. (Oil reservoir Port 1 fully open to Port C1.
50 psi.....	-----	{ Oil reservoir Port 2 fully open to Port C2.

53. Gun-Elevating Cylinder

a. Construction (fig. 80). The gun-elevating cylinder is double-acting, non-differential, hydraulic cylinder which elevates and depresses the gun. It is attached to a bracket on the lower edge of the turret by a clevis pin. The upper end is mounted in gimbals and attached to the gun by mounting brackets. Two oil lines, one for elevating and one for depressing the gun, are connected to passages drilled in the gimbal body and gimbal plate (fig. 81). The drilled passages open into annular grooves in the surface of the bearings

which support the gimbal pins of the cylinder upper cap. Passages are drilled in the pins of the cylinder upper cap. The passages drilled in the pin which fits into the gimbal plate open directly into the bore of the cylinder upper cap and the upper end of the cylinder. The passage in the pin which fits into the gimbal is drilled to the outer end of the pin and connects with the oil pressure tube running to a passage in the cylinder lower cap that connects with the bore of the cap and the lower end of the cylinder.

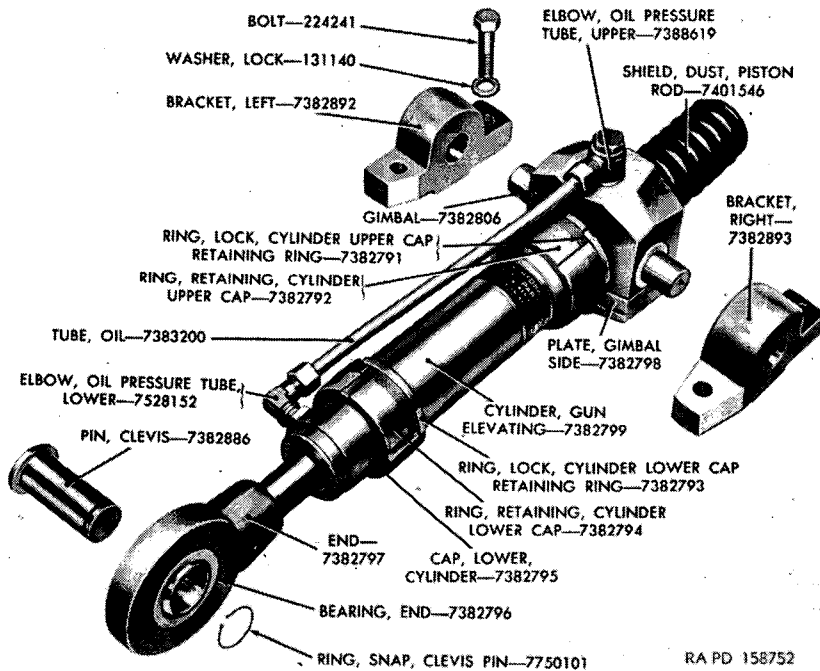
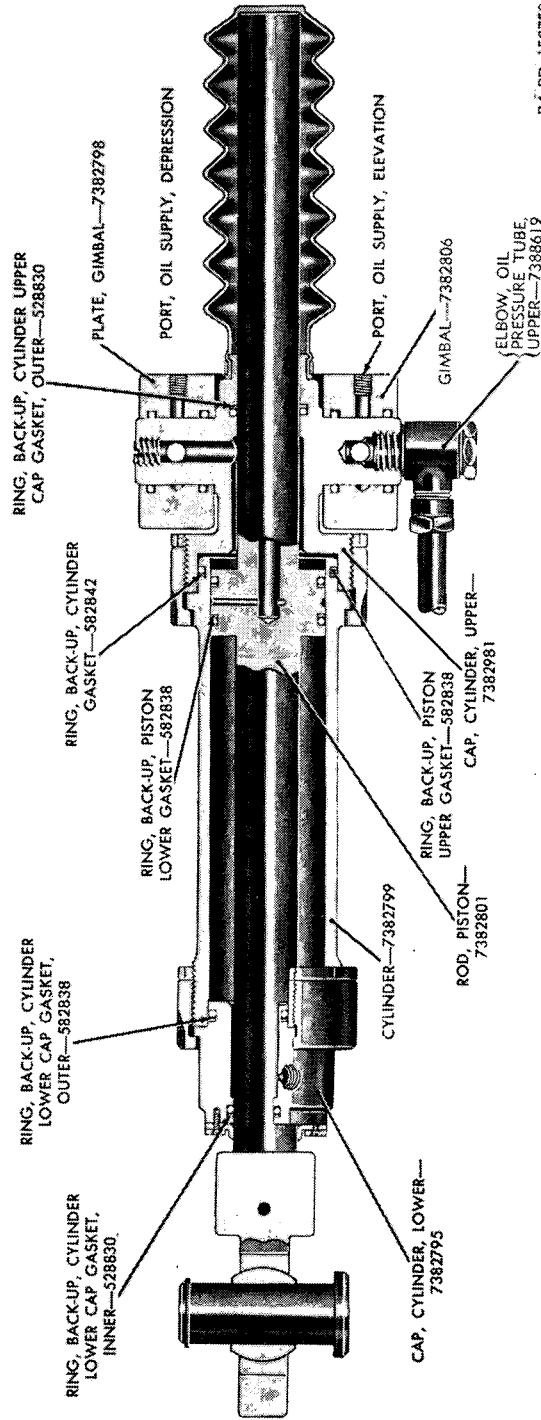


Figure 80. Gun-elevating cylinder.

b. Principles of operation (fig. 81).

- (1) *Depression.* The gun-elevating cylinder depresses the gun when oil from the selector valve supplied either by the hand-operated or hydraulic elevating pump is forced into the passage in the gimbal plate. The oil travels to the groove in the plate bearing. From the groove it flows into the passage in the pin of the cylinder upper cap and to the upper end of the cylinder. Oil pressure acting on the upper end of the piston rod forces the cylinder to rise on the piston rod raising the breech and depressing the gun. At the same time oil is flowing into the cylinder. Oil from the lower end of the cylin-



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Figure 8L. Gun-elevating cylinder—cross section.

[REDACTED]

der flows, through the passage in the cylinder lower cap, to the tubing connecting with the passage in the pin of the cylinder upper cap. From the passage in the pin the oil flows through the gimbal, the bypass safety valve, the hydraulic swivel joint, the selector valve and back to the oil pump (fig. 37).

- (2) *Elevation.* Reversal of the oil flow forces oil between the cylinder lower cap and the piston rod forcing the cylinder to descend on the piston rod elevating the gun.
- (3) *Oil circulation.* Due to the fact that the piston rod runs entirely through the cylinder, the volume of oil forced out of the cylinder when it is operated is equal to the amount forced in by the pump. This principle permits oil to be circulated directly from one end of the cylinder to the other in a closed hydraulic system with only an accumulator to allow for changes in volume due to temperature changes or leaks (par. 54).

c. Data.

Make-----Pacific Division, Bendix Aviation Corp
Ordnance part number----- 7382807
Length----- 30 in
Maximum width (over brackets)----- 9 in
Test pressure----- 6,000 psi
Overload pressure----- 3,000 psi
Operating pressure----- 2,000 psi

54. Hand-Operated Supercharge Pump, Accumulator, and Needle Valve

a. Construction.

- (1). *Hand-operated supercharge pump* (fig. 82). The hand-operated supercharge pump is a double-acting, piston-type pump, fitted with an extension-type handle. It is connected into the manual-hydraulic gun-elevating system between the power pack oil reservoir and the accumulator (fig. 37). A needle valve is connected into the oil lines as a pump by-pass.
- (2) *Accumulator* (fig. 82). The accumulator is a 10 cu-in cylindrical reservoir. It contains a plastic bag which is pre-charged with an insert gas when the accumulator is installed. The accumulator is connected into the oil lines of the manually operated gun-elevating system between the hand-operated supercharge pump and the hand-operated elevation pump. The lower end of the accumulator, to which the oil line is connected, is fitted with an oil port.

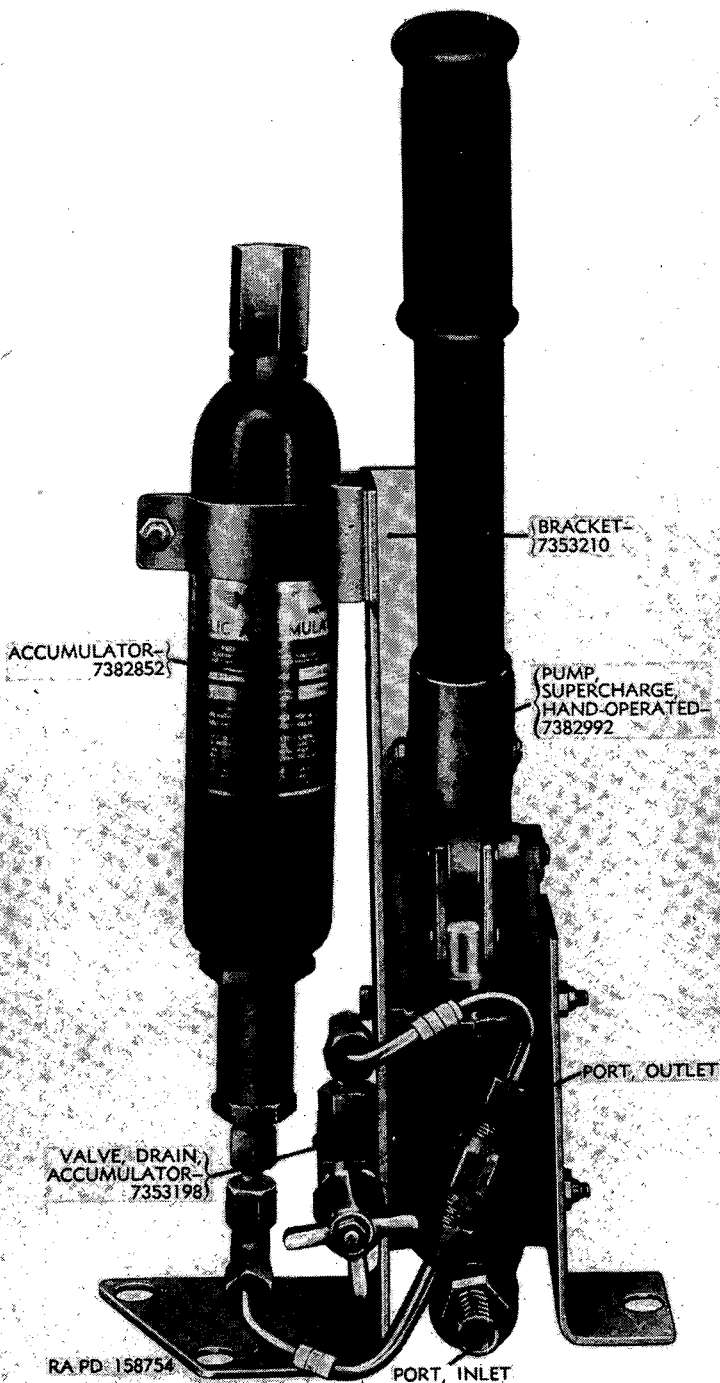


Figure 82. Hand-operated supercharge pump and accumulator.

- (3) *Needle valves.* The needle valves are high pressure, taper seat, semi-metering valves. Three needle valves are used in the gun-elevating system. One needle valve (accumulator drain valve) is in the bypass line around the hand-operated supercharge pump (fig. 37). A second needle valve (equalizing valve) is connected between the supercharge oil line from the accumulator and gun-depressing oil pressure line (fig. 37). The third needle valve (supercharge valve) is mounted on the selector valve in the gear-pump pressure line from oil reservoir port 12 (fig. 37).

b. Principles of Operation.

- (1) *Hand operated supercharge pump* (fig. 82).

(a) When the lever of the supercharge pump is operated, oil is drawn from a line connected to the oil reservoir port 15 (fig. 37) through the inlet port to the inlet valve of the pump into the pump cylinder as the pump piston rod is on its outward stroke. At the start of the inward stroke, the inlet valve seats trap the oil which has been drawn from the oil reservoir in the pump cylinder. Inward movement of the pump piston rod forces the outlet valve in the piston rod off its seat and oil flows past the valve through ports in the piston rod to the space in the cylinder between the packing gland and the piston rod head. Due to the size of the piston rod, the volume of the space in this outer portion of the cylinder, is less than enough to accommodate the oil being forced through the outlet valve from the inner part of the cylinder. This excess oil is forced out the outlet port of the pump into the line leading to the accumulator (fig. 37). On the next outward strokes of the piston rod oil is drawn into the cylinder as described above and at the same time since the outlet valve has now closed, the remaining oil in the outer portion of the cylinder is now forced out the outlet port to the accumulator. Since oil is discharged on each stroke of the pump, the hand-operated supercharge pump is considered a double-acting pump.

(b) The hand-operated supercharge pump is used to pump oil from the oil reservoir (fig. 37) into the accumulator. The pump is operated until the desired pressure is present in the accumulator and the manual-hydraulic gun-elevating system. It is also operated whenever it is necessary to restore loss in pressure from any cause.

- (2) *Accumulator* (fig. 83). The accumulator serves two purposes: It stores oil and maintains pressure in the manual-hydraulic gun-elevating system acting as a high-pressure storage reservoir. The accumulator supplies oil to the system at the pressure to which it has been charged until the oil level falls below the level of the poppet, at which point the nitrogen in the bag can no longer expand and the pressure in the system will fall. Excess oil from the system, caused by inequalities of the volume of the components or changes in temperature, can also be absorbed by the accumulator. The accumulator, in this way, permits the manual-hydraulic gun-elevating system to be operated as a closed system under a static supercharge pressure. The accumulator contains a bag which is precharged with nitrogen to approximately one-half the operating pressure of the hydraulic system before operation. The nitrogen expands the bag to fill the entire accumulator shell; it is prevented from escaping into the oil line by the poppet which closes whenever the oil level in the accumulator drops below the level of the poppet. When oil from the power pack oil reservoir is forced by the hand-operated supercharge pump into the accumulator bag, the oil flows into the accumulator and compresses the nitrogen in the bag. The more oil that is forced into the accumulator, the more the nitrogen is compressed and the greater the pressure in the accumulator.
- (3) *Needle valves*. The needle valves are used to permit or shut off flow of oil through the oil lines to which they are connected (a(3) above).
- (a) One needle valve (accumulator drain valve) is connected in piping which forms a bypass around the hand-operated supercharge pump (fig. 37). This valve is opened when the system is to be drained since oil cannot flow in a reverse direction through the pump due to the arrangement of the outlet and inlet valves.
- (b) A second needle valve (equalizing valve) is connected in a line which connects the supercharge line from the accumulator to the gun-depressing oil pressure line between the hand-operated elevating pump and selector valve (fig. 37). This valve is opened momentarily when changing from power to manual-hydraulic gun-elevating to equalize the pressure across the hand-operated elevating pump and to supercharge the entire manual-hydraulic gun-elevating

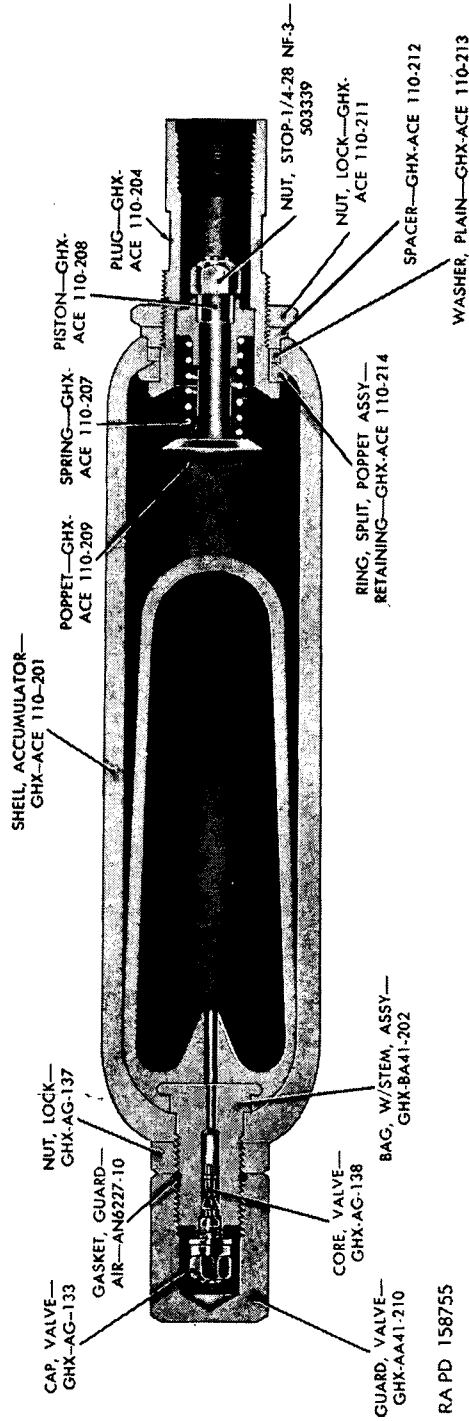


Figure 83. Accumulator—cross section.

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system easing the load on the hand-operated elevating-pump handle.

- (c) The third needle valve (supercharge valve) is installed at the selector valve in the gear-pump supercharge line from the oil reservoir port 12 (fig. 37). When pressure is produced by the power pack gear pump, it flows into this line, through the needle valve (supercharge valve), into the selector valve, and shifts the selector valve from manual-hydraulic to power gun-elevation. The valve is closed after the shift has been made by the selector valve to prevent vibration of the gun during elevation or depression.

c. Data.

Hand-operated supercharge pump:

Make----- Bendix Aviation Corp
Ordnance part number----- 7382992
Operating pressure----- 3,000 psi
Test pressure----- 4,500 psi
Displacement per stroke----- $\frac{3}{4}$ cu-in
Inlet port----- $\frac{3}{8}$ in tube
Outlet port----- $\frac{1}{4}$ in tube
Weight----- 3.20 lb

Accumulator:

Make----- Greer Hydraulics Inc
Model----- 30 A-C10-TA
Ordnance part number----- 7382582
Operating pressure----- 1,900 psi
Test pressure----- 3,000 psi
Overall length----- 12 in
Outside diameter----- 2 in

Needle valves:

Make----- Weatherhead Co
Model----- Parker No. 128
Ordnance part number----- 7353198
Test pressure----- 3,000 psi
Zero leakage at stem and needle----- 1,500 psi

55. Hand-Operated Elevating Pump and Locking Valve

a. Construction.

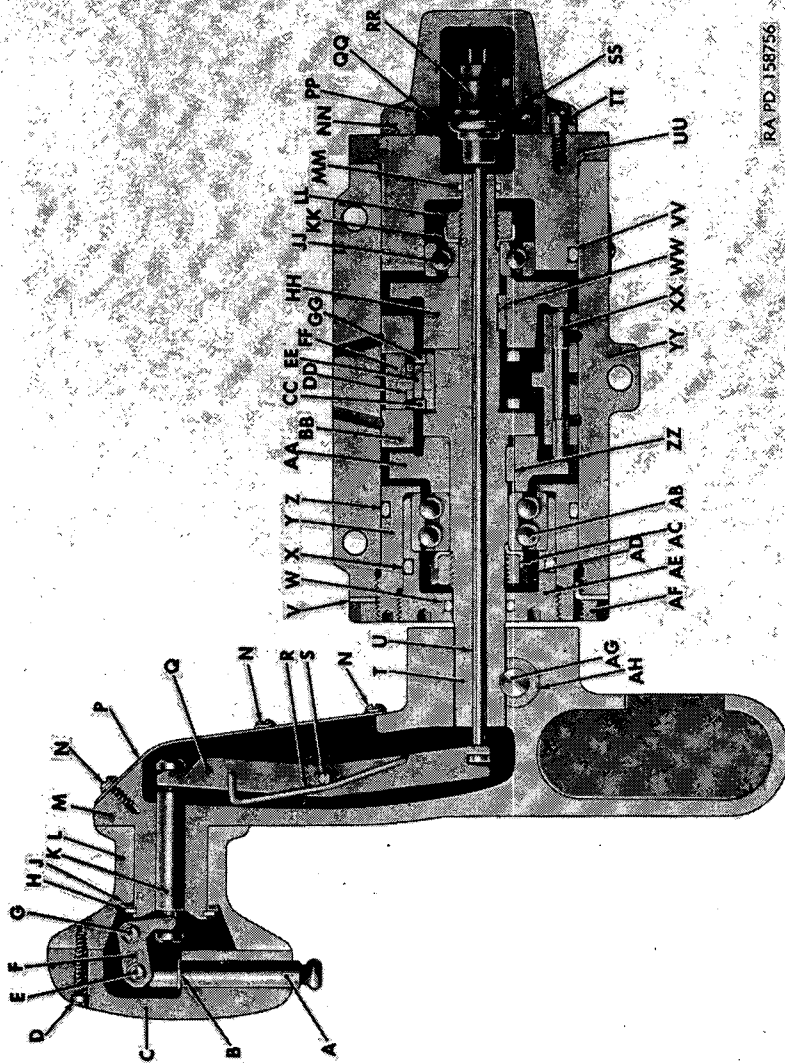
- (1) *Hand-operated elevation pump.*

Note. All key letters refer to figure 84.

The hand-operated elevating pump (fig. 37) is a constant displacement, reversible, multiple cylinder, slide valve, type of

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pump. The hand-operated pump housing contains three exterior mounting bosses and three oil ports. Two of the oil ports are in the mounting surface between the pump housing and the locking valve while the third port is located in a boss on the lower rear side of the pump housing. The two ports in the mounting surface between the pump housing and locking valve connect with bored grooves on the inside of the pump housing. A cylinder block (BB) located on the interior of the pump housing contains five pistons (FF), piston pins (EE), and slipper blocks (DD) that ride in the five radial cylinder bores. Through the body of the cylinder block (BB) and centered between each of the five cylinder bores are horizontally-drilled passageways that contain the five cylinder-block valves (YY). A series of five slots, equally spaced and cut to a depth of half the thickness of the body of the cylinder block, are centered around the outside circumference of the cylinder block. These slots independently connect each cylinder bore with one of the drilled cylinder block valve passageways. There are 10 additional slots cut into the outer circumference of the cylinder block, one on each side of the five center slots. These penetrate halfway into the horizontal valve passageways. The outer slots align with the two grooves on the inside of the pump housing. The slipper blocks pinned to the lower end of the radial pistons, are held in position and ride on the eccentric of the shaft. The five cylinder block valves are held in position by the front and rear valve plates (AA and HH). The faces of the valve plates that contact the cylinder-block valves (YY) are machined 3 degrees 49 minutes off the vertical center line of the shaft, but are keyed on the shaft so that their cam faces are parallel. The valve plates are secured by the inner races of the switch end and handle gum end ball bearings (JJ and AB) bearing lock nuts. The outer races of the two bearings are supported by the switch-end housing cap and the handle-arm-end-bearing retainer, respectively. The knob on the handle arm (M), contains a gun-firing push button (A) connected to a yoke that, in turn, engages a lever rod (K). One end of the firing-pin operating arm (Q) engages the lever rod (K) while the other end engages the firing pin (U). The firing pin extends through the center of the shaft (T) to the gun-firing button switch (RR). This switch is encased within the switch housing, mounted on the switch end housing cap (UU).



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Figure 84. Hand-operated elevating pump—cross section.

Figure 84—Continued

A—BUTTON, PUSH, GUN-FIRING—7363167	FF—PISTON—7363173
B—RING, SNAP, $\frac{1}{16}$ —583026	GG—RING, RETAINING, PISTON PIN, SWITCH END—7363163
C—CAP, KNOB—7363156	HH—PLATE, VALVE, REAR—7363154
D—SCREW, NO 4 (0.112)—40NC-2 x $\frac{3}{4}$ —131855	JJ—BEARING, BALL, JAN 131-01202-0000 (SWITCH END)—700445
E—PIN, $\frac{3}{16}$ x 1—141159	KK—WASHER, LOCK, SWITCH END BEARING—711202
F—YOKE—7363176	LL—NUT, LOCK, SWITCH END BEARING—711008
G—PIN, PIVOT, YOKE—141167	MM—GASKET (PACKING), O RING, $\frac{1}{16}$ IN THK, $\frac{3}{8}$ IN ID—501220
H—RING, SNAP—583382	NN—HOUSING, GUN-FIRING SWITCH—7363186
J—WASHER—738401	PP—GASKET, SWITCH, ASSY—7383414
K—ROD, LEVER—7363177	QQ—PLATE, MOUNTING, SWITCH—7383089
L—BASE, KNOB CAP—7363157	RR—SWITCH, GUN-FIRING—7380393
M—ARM, HANDLE—7363158	SS—SCREW, NO 4 (0.112)—40NC-2 x $\frac{1}{4}$ —133364
N—SCREW, NO 8 (0.164)—32NC-2 x $\frac{5}{16}$ —420428	TT—SCREW, NO 8 (0.164)—36NF-2 x $\frac{3}{8}$ —221108
P—COVER, HANDLE ARM—7363162	UC—CAP, HOUSING, SWITCH END—7363159
Q—ARM, OPERATING, FIRING PIN—7363169	VV—GASKET (PACKING), O RING, $\frac{1}{8}$ IN THK, 2 IN ID—546862
R—SPRING—7363168	WW—KEY, $\frac{1}{8}$ SQ x $\frac{3}{8}$ (VALVE REAR PLATE)—543208
S—PIN, 0.155 DIAM, $1\frac{1}{2}$ LG (PIVOT, LEVER ARM)—7363172	XX—HOUSING, HAND-OPERATED PUMP—7363147
T—SHAFT—7363148	YY—VALVE, CYLINDER BLOCK—7363164
U—PIN, FIRING—7363166	ZZ—KEY, $\frac{1}{8}$ SQ x $\frac{3}{8}$ (VALVE FRONT PLATE)—543208
V—WASHER, LOCK, CAP—7363175	AB—BEARING, BALL JAN 146-01732-0000 (HANDLE ARM END)—700192
W—GASKET (PACKING), O RING, $\frac{3}{32}$ IN THK, $\frac{1}{2}$ IN ID—501212	AC—WASHER, LOCK, HANDLE-ARM-END BEARING—711204
X—GASKET (PACKING), O RING, $\frac{1}{8}$ IN THK, $1\frac{1}{2}$ IN ID—501236	AD—NUT, LOCK HANDLE-ARM-END BEARING—711010
Y—CAP—7363152	AE—RETAINER, HANDLE-ARM-END BEARING—7363180
Z—GASKET (PACKING), O RING, $\frac{1}{8}$ IN THK, 2 IN ID—546862	AF—NUT, LOCK, CAP—7363174
AA—PLATE, VALVE, FRONT—7363153	AG—SCREW, HANDLE ARM—571279
BB—BLOCK, CYLINDER—7363149	AH—CLAMP, SLEEVE—7363187
CC—RING, RETAINING, PISTON PIN, HANDLE-ARM END—7363163	
DD—BLOCK, SLIPPER, PISTON-OPERATING—7363161	
EE—PIN, PISTON—7363193	

- (2) *Locking valve.* The locking valve is mounted on the hand-operated elevating pump and secured by six screws and lock washers. In the mating surface between the locking valve and elevating pump (fig. 37) are the two ports (port A and port B) (fig. 86) that aline with two ports in the elevating pump. Two additional ports (port B and port D) (fig. 87) are on the opposite side of the valve body and connect to lines from the selector valve. The ports are identified by the letters "A," "B," "C," and "D" stamped on the valve body so that the locking valve can be assembled to the elevating pump correctly. Through the center of the valve body is a horizontally drilled passageway that intercepts the four drilled passageways (fig. 87) from the ports and contains all the working parts of the valve. Centered between the ports, on the interior of the valve body, that connect with port A and port C is the locking valve piston (fig. 87). The piston is held between the ports under spring tension. This tension is afforded by a piston spring and sleeve on either side (fig. 87). The two sleeves screw into opposite ends of the valve body compressing the springs against the washers and piston. The two sleeves are held in their proper adjustment by lock units that tighten against the valve body. A ball in each sleeve acts as a valve and is held in position by a guide, spring, and cap (fig. 87). The caps screw into the sleeves and are secured by 3/8-24NF-3 nuts that tighten against the sleeve.

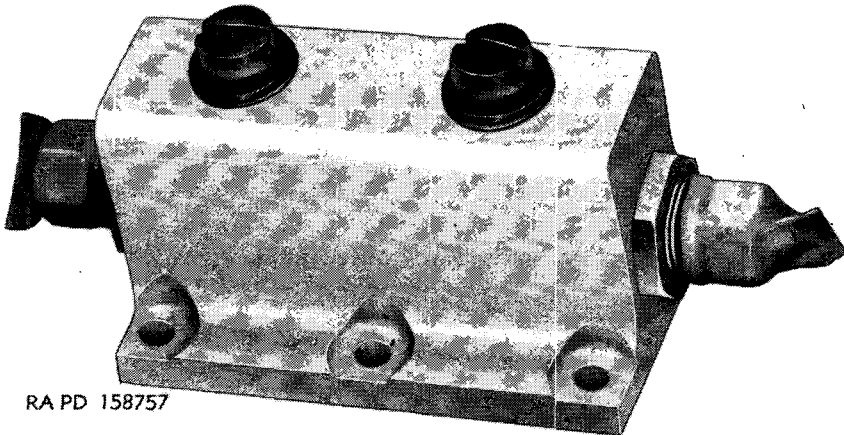
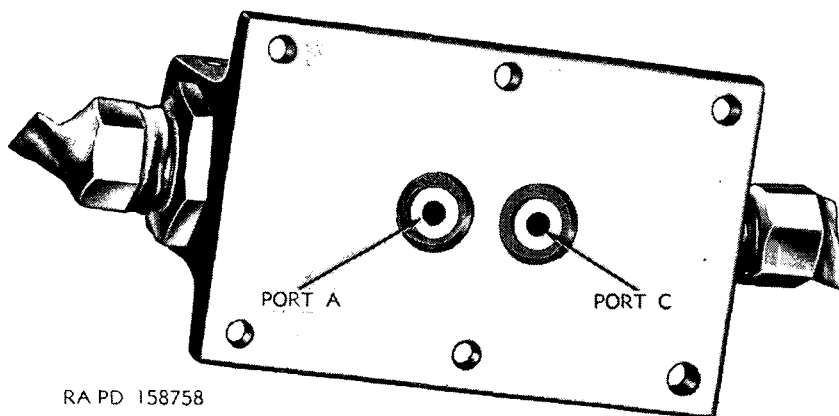


Figure 85. Locking valve.



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Figure 86. Locking-valve ports.

b. Principle of Operation.

(1) Hand-operated elevating pump.

Note. All key letters refer to figure 84.

- (a) Elevating or depressing.* The hand-operated elevating pump is in a closed hydraulic system (fig. 37), together with the locking valve, selector valve, hydraulic swivel joints, bypass safety valve, elevating cylinder, accumulator, and hand-operated supercharge pump. This manual-hydraulic system is operative only when the power pack is not in operation. Supercharging of the system is accomplished by the accumulator and hand-operated supercharge pump. The accumulator, connected to the hand-operated elevating pump, via the supercharge line, maintains a supercharge pressure throughout this closed system. The pumping action of the elevating pump determines the increase or decrease in the supercharge pressure plus the pressure of the pump acting on one or the other side of the elevating cylinder piston (FF) that causes the elevation cylinder to operate. This pumping action is determined by oil flow through the piston and valve chambers within the pump. As the shaft (T) is turned, the eccentric on the shaft as well as the front and rear valve plates (AA and HH) turn. Each piston (FF) in turn, moves to the top of its respective cylinder bore, back down to the bottom of the cylinder bore and then back to the top, completing the cycle of the piston. At the

same time that the pistons are moving through this cycle, their corresponding valves are moving by the action of the valve plates. When a piston is at the top of its stroke, its connecting valve is at the extreme end of its horizontal movement toward the switch end of the pump. As the piston moves down to the bottom of its stroke the cam action of the valve plates move the valve toward the handle-arm end. Then, as the piston moves to the top of its stroke, the valve moves in the opposite direction toward the switch end, completing its cycle. Thus, each of the five pistons and valves move through this cycle in sequence as the eccentric rotates. The direction in which the handle arm is rotated determines the direction of oil flow through the pump. Turning the handle arm in a clockwise direction causes oil to flow in the drilled passageway that connects to port A on the locking valve and around the groove on the interior of the elevating pump housing nearest the pump handle. The oil then passes into the five radial slots on the exterior of the cylinder block that match with the groove in the handle-arm end of the housing, the valves, or through the valve ports to the passageway on the exterior side of the cylinder block that connects with the chamber above the piston. As each piston moves outward toward the top of its stroke, its valve moves by the cam action of the front and rear valve plates toward the switch end of the housing. Oil on top of the piston is pushed through the center groove in the cylinder block (BB) as the valve moves toward the switch end, covering the oil port in front of the cylinder block, stopping the flow of oil from the front port of the cylinder block. At the same time the valve uncovers the oil port in the rear of the cylinder block, allowing the oil, under the increased pressure of the piston, to flow from the piston chamber through the rear valve passageway, into the rear slot in the cylinder block, around the rear groove in the pump housing and out the rear oil port that connects with port C in the locking valve (fig. 87). Then as the piston moves down in the cylinder bore and its valve moves toward the front, covering the port through which oil has just been expelled, and opens the front port admitting oil to the piston chamber, thus completing the piston and valve cycle. Therefore, when the handle arm (M) of the elevating pump is turned clockwise, oil pressure, from top

side of the piston in the elevating cylinder, that enters the elevating pump at port A from the locking valve (fig. 87), is decreased while the pressure on the other side of the pump or that which is being pumped through port C of the locking valve (fig. 87) which connects with the bottom side of the elevating cylinder piston, is increased. This change in pressure causes the gun to elevate. When turning the handle arm counterclockwise, the action of the pistons and valves admit oil from the rear oil port, that enters the pump housing at port C of the locking valve (fig. 87), and expels the oil through port A. Thus the direction of the oil flow is reversed, decreasing the oil pressure on the bottom side of the piston in the elevating cylinder and increasing the pressure on the top side of the piston. Thus, the gun will depress.

- (b) *Firing of the gun.* By depressing the gun firing push button (A) in the knob cap (C) of the hand-operated elevating pump handle, the pivoted "L" shaped yoke (F) pulls forward on the front end of the lever rod (K). The rear end of the lever rod then pulls one end of the lever arm (Q) forward. The lever arm being pivoted in the center then pushes on the firing pin (U). The firing pin moves through the center of the shaft (T) and strikes the spring-loaded push button firing switch (RR). This mechanism is spring-loaded (R) at the lever arm so that when the push button is released, all parts return to their normal position.
- (2) *Locking valve* (fig. 87). The locking valve, connected directly to the hand-operated elevating pump (fig. 37) is a hydraulically-operated valve that prevents the gun from driving the hand-operated elevating pump. The two ports in the mounting surface are termed port A and port C (fig. 86). The two exterior ports that connect to lines from the selector valve are termed port B and port D. Port A connects through a chamber in the valve with port B and port C connects to port D. In each chamber between the ports is a spring-loaded ball check valve. Oil under pressure can pass from port A through the valve to port B by opening the spring-loaded ball check valve. Likewise the same action can take place from port C to port D. Since the ball check valve is normally held closed under spring tension, oil cannot pass from port B to port A when the pressure at port B is greater than that at port A. The same condition exists

between port D and port C. Since this locking valve is in a closed system and operates between the hand-operated elevating pump and the selector valve, oil must pass through each valve passageway simultaneously, but in opposite directions. This action is accomplished by the piston that floats between the two spring-loaded valves. When the oil pressure at port A is greater than that at port C, caused by the pumping action of the hand-operated elevating pump, the piston within the housing will move toward the valve in the passageway between port C and port D. When moved far enough it will push the spring-loaded ball valve off its seat and oil will flow from port D to port C into the elevation pump. At the same time as the oil moves the piston, the piston unseats the ball valve between port A and port B thus allowing oil under pressure to pass from port A to port B. Likewise, oil under pressure at port C will reverse the action within the valve body whereby, oil entering port C will pass through the ball valve in the passageway between port C and port D and flow out port D. Simultaneous with this action, the piston will move toward the opposite end of the valve body, unseating the ball valve between port A and port B, permitting oil to flow from port B to port A back to the pump. Should the hand-operated elevating pump be in operation elevating the gun, the oil passage through the locking valve would be port B to port A into the elevating pump and from port C to port D out of the pump. If the gun should strike an exterior object that would tend to depress the gun, the back pressure of the oil at port D if greater than the pump pressure at port C would close the ball check valve between these two ports, preventing the handle arm of the elevating pump from reversing in direction. However, if the gun would strike an object that would tend to elevate the gun, the oil pressure at port B would be increased. Should this increase in pressure be greater than the pump pressure at port C this would close the ball check valve between port B and port A, thus cutting off the incoming oil to the elevating pump. The reverse action would also take place in the locking valve when the gun is being depressed by the hand-operated elevating pump.

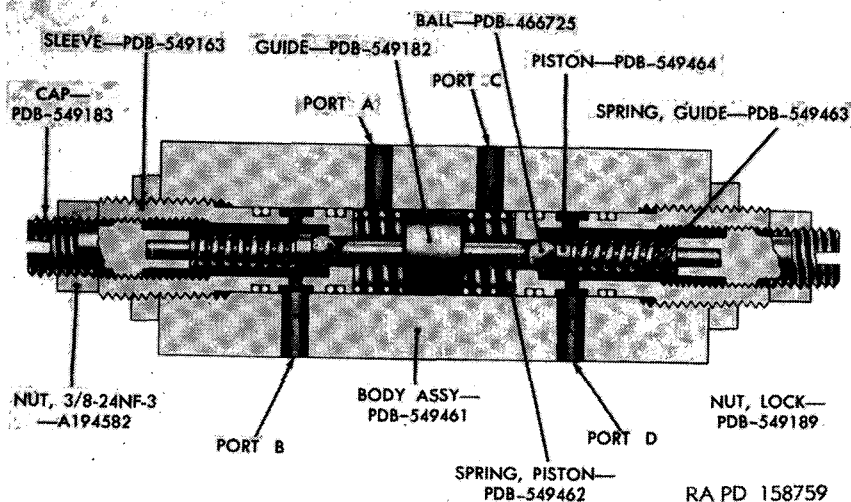


Figure 87. Locking valve—cross section.

c. Data.

Hand-operated elevating pump:

Make..... Clinton Machine Co
 Ordnance No..... 7363146
 Displacement..... 4 cu-in/rev
 Overall length..... 11 $\frac{3}{4}$ in
 Length of pump..... 6 $\frac{29}{32}$ in

Locking valve:

Make..... Bendix Aviation Corp
 Ordnance No..... 7382996
 Overall length..... 5 $\frac{1}{8}$ in
 Length of pump body..... 3 $\frac{1}{2}$ in

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